GOVERNMENT OF SINDH

Sindh Mass Transit Authority

Request For Proposals
Works (Design and Build)

RFP No.: PK-SMTA-334960-CW-RFP
Loan No.: IBRD-89950

Procurement of Package - 4: NEW JAM SADIQ BRIDGE (Yellow Corridor Segment 3)

KARACHI MOBILITY PROJECT

Volume 5

5A - Geotechnical Investigation
5B - Hydrology and Hydraulics Study Report
5C - Environmental and Social Management Plan
5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

Project Director (Karachi Mobility Project)
Bus Rapid Transit (BRT) "Yellow Line"
Sindh Mass Transit Authority, Karachi-Pakistan

Issued on: March 2023

Request For Proposal Documents Works (Design and Build)

Main Contents

VOLUME (1): **Instructions to Proposers (ITP) & Proposal Data Sheet (PDS), Proposal Forms / Schedules, Conditions of Contract, Contract Forms / Schedules**

Part 1 - Request for Proposal Procedures
Section I Instructions to Proposers (ITP)
Section II Proposal Data Sheet (PDS)
Section III Evaluation and Qualification Criteria
Section IV Proposal Forms
Section V Eligible Countries
Section VI Fraud and Corruption

Part 2 - Employer's Requirements
Section VII Employer's Requirements

Part 3 - Conditions of Contract and Contract Forms
Section VIII General Conditions (GC)
Section IX Particular Conditions (PC)
Section X Contract Forms

VOLUME (2):

Part (A) Employer's Requirements
1) Introduction
2) General Overview of the Project
3) Design Intent
4) Design Responsibility
5) Interface Management
6) Design Stages and Deliverables
7) Basis of Design

Part (B) Specifications (1 of 2)
Division 01 - General Requirements

Part (B) Specifications (2 of 2)
Division 02 - Site Construction
Division 03 - Concrete
Division 07 - Thermal and Moisture Protection
Division 26 - Electrical
Division 31 - Earthwork
Division 32 - Exterior Improvements
Division 33 - Utilities
Division 34 - Transportation

VOLUME (3): Schedule of Priced Activities

Basis of Pricing

Pricing Preambles
1 Design & Special Works
2 Bridge Works
3 Roadworks
4 Electrical Works
5 Utilities

Pricing Schedules

Summary
1 General and Particular Conditions of Contract
2 General Requirements
3 Design & Special Works
4 Bridge Works
5 Roadworks
6 Electrical Works
7 Utilities

VOLUME (4): Drawings

01- Roads
02- Bridge
04- Utilities

VOLUME (5): Technical Documents "For Information":

5A - Geotechnical Investigation
5B - Hydrology and Hydraulics Study Report
5C - Environmental and Social Management Plan
5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

TABLE OF CONTENTS

REF **DIVISION** - SECTION TITLE

TECHNICAL DOCUMENTS
"For Information"

VOLUME 5A GEOTECHNICAL INVESTIGATION

VOLUME 5B HYDROLOGY AND HYDRAULICS STUDY REPORT

VOLUME 5C ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

VOLUME 5D STRUCTURE CONDITION SURVEY – EXISTING JAM SADIQ BRIDGE ASSESSMENT & REHABILITATION REPORT

Volume 5A - Geotechnical Investigation

2019

K19-1092-101

Geotechnical Investigation Report for Bus Rapid Transit System (BRTS), Yellow Line (from Dawood Chorangi to Numaish Chorangi and Regal Chowk via 8000 Road, Korangi Road & FTC), Karachi

Client: Sindh Mass Transit Authority

Consultant: NESPAK

October

SOIL TESTING SERVICES

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SOIL TESTING SERVICES	Geotechnical Investigation Report	Revision	
		#	Date
	Report No.: Vol I	03	28/11/2019

PROJECT: Geotechnical Investigation for Bus Rapid Transit System (BRTS), Yellow Line (from Dawood Chowrangi to Numaish Chorangi and Regal Chowk via 8000 Road, Korangi Road & FTC), Karachi

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APPROVED BY: (Chief Executive Officer)	Ali Zaidi		

ISSUE/REVISION INDEX

Issue Code	Revision					Revision Details
	No.	By	Rev'd.	App.	Date	
RD	00	AR	NA	AZ	22/10/2019	
RD	01	AR	NA	AZ	14/11/2019	Comments incorporated.
RD	02	AR	NA	AZ	18/11/2019	Comments incorporated.
RD	03	AR	NA	AZ	28/11/2019	Comments incorporated.

Issue Codes: RC = Released for Construction, RD = Released for Design, RF = Released for Fabrication, RI = Released for Information, RP = Released for Purchase, RPA = Released for Permit Application, RQ = Released for Quotation, RR = Released for Review and Comments.

SOIL TESTING SERVICES

EXECUTIVE SUMMARY

Geotechnical Investigation for Bus Rapid Transit System (BRTS), Yellow Line (from Dawood Chowrangi to Numaish Chowrangi and Regal Chowk via 8000 Road, Korangi Road, Karachi, was carried out in order to determine geotechnical parameters of subsurface deposits. Scope of field work included drilling of twenty seven (27) boreholes up to the maximum 40 meters depth below the existing ground level along with excavation of seventeen (17) test pits up to the maximum depth of 2.0 meters. Soil, rock and ground water samples were collected during field investigation. Laboratory testing of these samples has been carried out in the Soil Testing Services' laboratory, Karachi.

The deposition of the area mainly consists of *'loose to very dense,* fine to coarse grained sand, clayey sand*,' 'soft to hard,* silty and sandy clay'*, 'very soft to hard,* sandy clayey silt*', 'very dense,* fine to coarse grained sandy gravel', highly weathered and fractured pieces of sandstone, friable sandstone'*, 'extremely weak,* moderately weathered and fractured claystone*' and '*highly weathered and fractured mudstone*'.* Groundwater table was encountered at a depth range of 0.76 to 0.91 meters below the existing ground level in four (04) out of total twenty seven (27) boreholes drilled during the time of this investigation. Perched water table was also encountered in twelve (12) borehole, at a depth range of 0.61 to 11.5 meters below the existing ground level. However, this may fluctuate due to seasonal and other environmental variations.

Keeping these conditions under consideration:

- Allowable bearing pressures have been given for shallow foundations at a depth of 1.5 – 2.0 m below existing ground level, for stations.
- Liquefaction potential of all boreholes is assessed and results are discussed in section 5.8 of the report.
- Allowable pile capacities have been provided for various diameters and depths, for proposed bridge location and liquefaction susceptible locations.
- Earth pressure parameters for excavation support system and earth retention have been provided for proposed underpass locations.
- Recommendations for soil improvement is provided in section 5.9 of the report.
- Seismic soil profile has been taken as 'S_C' and 'S_D' for the foundations in accordance with UBC-97.

- Results of earthwork tests like Modified Proctor and CBR are also summarized in the report.

The exposure of underground concrete to aggressive chemicals is found to be '*negligible to moderate'* for soil and water samples*, respectively,* for sulphates and chlorides which have influenced the selection of cement and it is recommended to use *Ordinary Portland Cement with slag or* any other appropriate cement replacement material *like GGBFS, fly ash, micro silica, etc.* for all underground concrete works below water table. However, for underground construction above water table, *Ordinary Portland Cement (OPC)* shall be used.

CONTENTS

S.NO.	SECTION	PAGE NO.
1.	**INTRODUCTION**	**6**
2.	**THE SITE**	**7**
3.	**GEOLOGICAL DESCRIPTION OF THE AREA**	**8**
4.	**GROUND CONDITIONS**	**9**
4.1	FILL MATERIAL	9
4.2	SAND	10
4.3	CLAY	13
4.4	SILT	14
4.5	GRAVEL	15
4.6	MUDSTONE	16
4.7	CLAYSTONE	16
4.8	SANDSTONE	17
4.9	LIMESTONE	17
4.10	GROUNDWATER CONDITIONS	18
5.	**ENGINEERING DESIGN CONSIDERATIONS**	**19**
5.1	DESIGN PARAMETERS	19
5.2	DESIGN CRITERIA FOR SHALLOW FOUNDATIONS	27
5.3	ALLOWABLE BEARING PRESSURES FOR SHALLOW FOUNDATION	28
5.4	DEEP FOUNDATIONS - ALLOWABLE PILE CAPACITIES	46
5.5	RECOMMENDED DRILLING METHOD AND CONFIRMATORY TESTING	48
5.6	PILE CONSTRUCTION	48
5.7	EARTH RETAINING STRUCTURE	49
5.8	LIQUEFACTION POTENTIAL OF SOIL	52
5.9	SOIL IMPROVEMENT	53
	5.9.1 STONE COLUMNS	53
	5.9.2 FIELD TESTING FOLLOWING SOIL IMPROVEMENT	55
5.10	ALLOWABLE BEARING PRESSURES FOR SHALLOW FOUNDATION AFTER SOIL IMPROVEMENT	55
5.11	SOIL PROFILE TYPE (ACCORDING TO UBC-97)	55
	5.11.1 SEISMIC ZONE FACTOR	55
	5.11.2 SOIL PROFILE TYPE	56
	5.11.3 SEISMIC COEFFICIENTS	56

5.12 TYPE OF CEMENT 56
5.13 DISCUSSION ON TEST PITS AND EARTH WORK TESTS 56
6. CONCLUSIONS 59

APPENDIX A BOREHOLE LOCATION PLAN
APPENDIX B BOREHOLE & TEST PIT LOGS
APPENDIX C SOIL PROFILES
APPENDIX D LABORATORY TEST RESULTS
APPENDIX E GENERAL INFORMATION ON TESTING PROCEDURES
APPENDIX F CALCULATIONS FOR PILE FOUNDATION
APPENDIX G LIQUEFACTION POTENTIAL
APPENDIX H BEARING CAPACITY CALCULATIONS

1. INTRODUCTION

Planning for Bus Rapid Transit System (BRTS), Yellow Line (from Dawood Chowrangi to Numaish Chorangi and Regal Chowk via 8000 Road, Korangi Road, Karachi is underway. In order to determine the geotechnical parameters of the subsurface deposits, *M/s. Soil Testing Services (STS)* were entrusted by *M/s. Nespak* to perform the geotechnical investigation at the project site. M/s. NESPAK are the consultants for the project.

Scope of field work included drilling of twenty seven (27) boreholes up to the maximum 40 meters depth below the existing ground level. Seventeen (17) test pits were also excavated up to 2.0 meters depth below the existing ground level. Boreholes and test pits were marked in the field by STS geologist based on the coordinates provided by the NESPAK. Elevations of each borehole w.r.t to the MSL was noted by the STS geologist and mentioned in the borehole logs appended with this report. In each borehole, Standard penetration tests were carried out along with the collection of soil samples via split spoon sampler. Boreholes in rock were advanced through continuous coring. Rock core samples was carried out with the help of core barrel. Ground water samples were also collected from the boreholes drilled at site. The samples retrieved from the field work were tested in the laboratory and this report is prepared from the information obtained from the field and laboratory tests.

The report consists of five chapters with *Chapter 2* describing the site's existing condition, *Chapter 3* discusses the regional geology briefly, *Chapter 4* discusses the subsurface deposits in detail, *Chapter 5* includes the recommendations for foundation design, and *Chapter 6* contains a summary of conclusions regarding the ground conditions, with respect to geotechnical engineering for this project.

2. THE SITE

Bus Rapid Transit System (BRTS) Yellow Line is a 26.0 Km route (approx.) starting from Dawood Chowrangi to Numaish Chowrangi, Karachi. Soil investigation was carried out along Korangi road to Numaish Chowrangi. Geographically the site is located in the eastern part of the Karachi city.

Major landmarks located along the proposed route includes Getz Pharma, Singer Pakistan Limited, Allied Engineering & services, NMC Hospital.

Figure 2.1 shows the google image of the site.

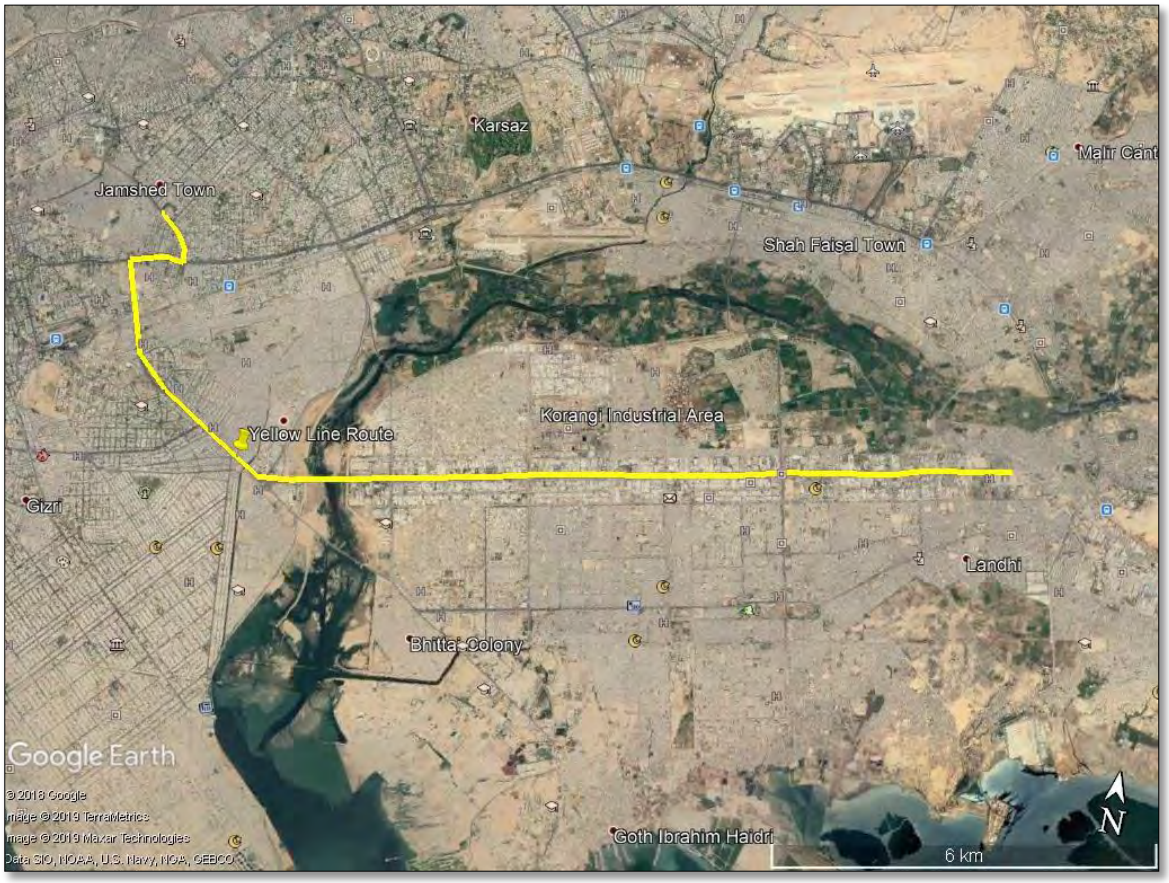
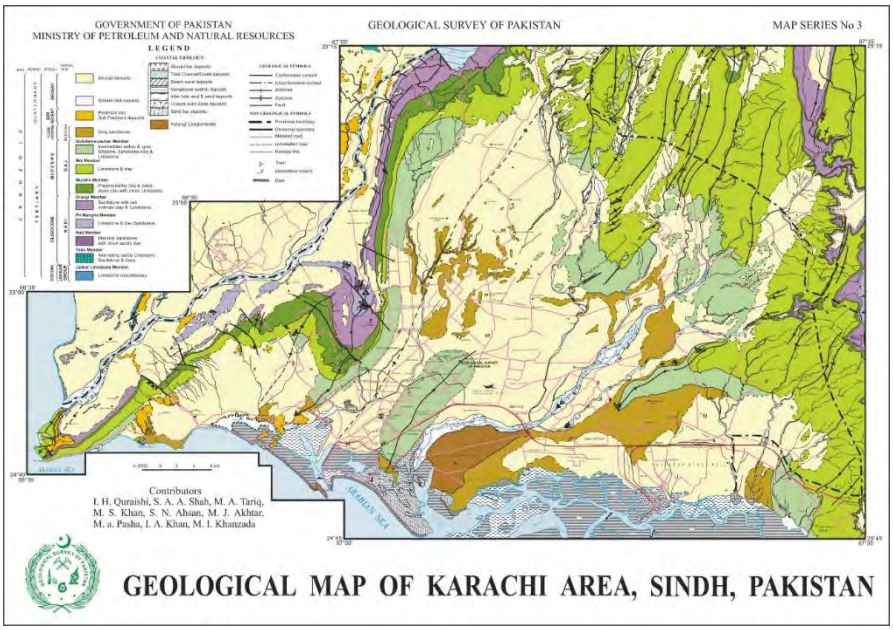


Figure 2.1: Satellite image of site

3. GEOLOGICAL DESCRIPTION OF THE AREA

The proposed BRTS Yellow line route start point is Dawood Chowrangi and the BRT service start point is Mansehra Colony. The BRT route from Mansehra Colony (BRT service start point)runs through FTC, Shahrah-e-Faisal, Shahrah-e-Quaideen up to Khudadad Chowrangi from where it takes Kashmir Road to People's Roundabout and then to Regal Chowk through New M.A. Jinnah Road / Preedy Street. From Regal Chowk it turns back following the same route up to Shah Ahmad Noorani Chowrangi and ends at Numaish. Deposit of this Karachi region represents mainly Middle and Upper Tertiary age deposits.

According to Geological Survey of Pakistan, area under study mainly consists of alluvial deposits up to the depth of 20.0 to 25.0 meters from Dawood Chowrangi to Malir River towards west. Bed rock present at the project location is of Gaj Formation of Lower Age Miocene. Gaj formation consists of shale with subordinate sandstone and limestone. Moving towards Malir River, one of the two rivers that passes through the city of Karachi drains into the Arabian Sea via Ghizri creek, deposits of Sandstone of Manchar Formation (Quaternary age) and near Malir River deposits of Korangi Conglomerate are found at the surface. On the other bank of the river siltstone, limestone, sandstone and clay of Gulistan e Johar member of Gaj Formation are deposited and exposed at different locations.


GOVERNMENT OF PAKISTAN
MINISTRY OF PETROLEUM AND NATURAL RESOURCES
GEOLOGICAL SURVEY OF PAKISTAN
MAP SERIES No 3
LEGEND
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GEOLOGICAL MAP OF KARACHI AREA, SINDH, PAKISTAN

Figure 3.1: Karachi Geological Map

4. GROUND CONDITIONS

The subsurface deposits up to the explored depth consist of the following units:

- Fill Material
- Sand
- Clay
- Silt
- Gravel
- Mudstone
- Claystone
- Sandstone
- Limestone

Following sub-sections describe the characteristics of the geological units and the groundwater conditions. All rocks are classified as per BS-5930 and soils as per Unified Soil Classification System (USCS).

4.1 FILL MATERIAL

Deposits of filling material including fine to coarse grained sandy gravel, concrete and asphalt. These deposits were found up to the maximum depth of 1.5 meter. Table 4.1 summarizes the details of these deposits.

Table 4.1 Deposits of Filling Material

Borehole No.	Depth (meters)
BH-01	0.0 – 0.6
BH-02	0.0 – 0.5
BH-03	0.0 – 0.5
BH-06	0.0 – 0.5
BH-07	0.0 – 0.5
BH-08	0.0 – 1.2
BH-10	0.0 – 1.5

Borehole No.	Depth (meters)
BH-11	0.0 - 2.5
BH-12	0.0 – 1.5
BH-13	0.0 – 0.25
BH-14	0.0 – 0.25
BH-15	0.0 – 0.25
BH-17	0.0 – 0.5
BH-18	0.0 – 0.5
BH-19	0.0 – 0.5
BH-20	0.0 – 0.2
BH-21	0.0 – 1.5
BH-22	0.0 – 2.1
BH-23	0.0 – 0.5
BH-24	0.0 – 0.4
BH-25	0.0 – 0.3
BH-26	0.0 – 0.5
BH-27	0.0 – 0.3

4.2 SAND

Deposits of fine to coarse grained sand with silt, clay and gravel (poorly graded to well graded) were found in all the boreholes except borehole no.18 drilled at the site. State of compactness according to SPT 'N' counts has been determined as *'very loose to very dense'*. The grain size analysis of these deposits was carried out in the laboratory. Unified Classification System (UCS) classifies these deposits as *'SM', 'SC', 'SW', 'SW-SM', 'SP' and 'SP-SM'*. Table 4.2 summarizes the details of these deposits.

Table 4.2 Deposits of Sand

Borehole No.	Depth (meters)
BH-01	1.5 – 10.0
BH-02	1.5 – 10.5 13.3 – 16.7
BH-03	0.5 – 6.5
BH-04	0.0 – 13.2 17.7 – 20.0
BH-05	0.0 – 10.0
BH-06	0.5 – 2.5 3.5 – 6.5 9.5 – 11.5 13.5 – 16.4
BH-07	0.5 – 3.5 4.5 – 6.5 8.5 – 12.5 13.8 – 16.4
BH-08	1.2 – 1.6 2.5 – 5.5 8.5 – 10.0
BH-09	0.0 – 2.5 4.5 – 6.5 8.5 – 16.2
BH-10	5.5 – 8.2
BH-11	2.5 – 4.5 6.5 – 10.0
BH-12	1.5 – 7.2 8.2 – 9.5 11.5 – 14.5 16.5 – 18.2

Borehole No.	Depth (meters)
BH-13	0.25 – 3.5 5.5 – 6.5 7.5 – 12.5 17.2 – 20.5
BH-14	0.25 – 2.5 5.5 – 9.0 9.5 – 11.0 17.5 – 18.5 20.0 – 22.0
BH-15	0.25 – 3.5 5.2 – 8.0 12.5 – 15.2
BH-16	0.0 – 2.5 3.5 – 6.9 7.5 – 12.5 16.5 – 24.2
BH-17	0.5 – 2.5 11.5 – 12.0
BH-19	2.5 – 3.5 4.5 – 10.0
BH-20	0.2 – 5.4 6.4 – 8.9 10.5 – 12.0
BH-21	5.2 – 10.0
BH-22	2.1 – 2.5 3.5 – 7.10
BH-23	0.5 – 1.5
BH-24	0.4 – 8.4
BH-25	0.3 – 8.2
BH-26	0.5 – 5.2 8.2 – 9.5

Borehole No.	Depth (meters)
BH-27	1.5 – 3.5 4.5 – 5.5 6.5 – 12.0

4.3 CLAY

Deposits of silty clay, sandy silty clay were found in fourteen boreholes drilled at the site. State of compactness according to SPT 'N' counts has been determined as *'soft to hard'*. The grain size analysis of these deposits was carried out in the laboratory. Unified Classification System (UCS) classifies these deposits as *'CL' and 'CL-ML'*. Table 4.3 summarizes the details of these deposits.

Table 4.3 Deposits of Clay

Borehole No.	Depth (meters)
BH-02	0.5 – 1.5 10.5 – 13.3
BH-03	8.5 – 10.0
BH-04	14.3 – 17.7
BH-06	7.4 – 9.5 11.5 – 13.5 18.5 – 20.0
BH-09	6.5 – 8.5
BH-10	8.2 – 9.5
BH-12	18.2 – 20.0
BH-17	2.5 – 5.5
BH-18	4.5 – 7.5
BH-21	1.5 – 2.5
BH-22	2.5 – 3.5
BH-23	2.5 – 7.5

Borehole No.	Depth (meters)
BH-26	5.2 – 8.2

4.4 SILT

Deposits of fine grained sandy silt with some clay, fine grained sandy clayey silt and clayey silt with some sand were found in twenty two boreholes drilled at the site. State of compactness according to SPT 'N' counts has been determined as *'very soft to hard'.* The grain size analysis of these deposits was carried out in the laboratory. Unified Classification System (UCS) classifies these deposits as *'ML'.* Table 4.4 summarizes the details of these deposits.

Table 4.4 Deposits of Silt

Borehole No.	Depth (meters)
BH-01	0.6 – 1.5
BH-02	16.7 – 20.0
BH-03	6.5 – 8.5
BH-06	2.5 – 3.5 17.3 – 18.5
BH-07	3.5 – 4.5 6.5 – 8.5 16.4 – 20.0
BH-08	1.6 – 2.5 5.5 – 8.5
BH-09	2.5 – 4.5 16.2 – 20.0
BH-10	1.5 – 5.5
BH-11	4.5 – 6.5
BH-12	7.2 – 8.2 9.5 – 11.5 14.5 – 16.5

Borehole No.	Depth (meters)
BH-13	3.5 – 5.5 6.5 – 7.5 12.5 – 17.2 20.5 – 24.7
BH-14	2.5 – 5.5 9.0 – 9.5 11.0 – 17.5 18.5 – 20.0
BH-15	3.5 – 5.2 8.0 – 12.5 15.2 – 25.2
BH-16	2.5 – 3.5 7.0 – 7.5 12.5 – 16.5
BH-17	5.5 – 11.5
BH-18	0.5 – 4.5
BH-19	0.5 – 2.5
BH-20	5.4 – 6.4
BH-21	2.5 – 5.2
BH-23	1.5 – 2.5
BH-26	9.5 – 11.0
BH-27	0.3 – 1.5 3.5 – 4.5 5.5 – 6.5

4.5 GRAVEL

Deposits of fine to coarse grained sandy gravel were found in four boreholes drilled at the site. State of compactness according to SPT 'N' counts has been determined as *'very dense'*. The grain size analysis of these deposits was carried out in the laboratory. Unified Classification System (UCS) classifies these deposits as *'GM'*. Table 4.5 summarizes the details of these deposits.

Table 4.5 Deposits of Gravel

Borehole No.	Depth (meters)
BH-06	6.5 – 7.4 16.4 – 17.3
BH-07	12.5 – 13.8
BH-19	3.5 – 4.5
BH-20	8.9 – 10.5

4.6 MUDSTONE

Deposits of mudstone were recovered from only five boreholes drilled at the site. Disturbed and undisturbed rock core samples were collected from these deposits which were tested for moisture content, density and unconfined compressive strength. These deposits are classified as *'extremely weak to very weak'* according to BS-5930. Table 4.6 summarizes the details of these deposits.

Table 4.6 Deposits of Mudstone

Borehole No.	Depth (meters)
BH-13	24.5 – 29.0
BH-15	25.2 – 30.0
BH-18	14.0 – 18.0
BH-22	7.10 – 10.0
BH-23	10.0 – 14.0

4.7 CLAYSTONE

Deposits of claystone were recovered from only three boreholes drilled at the site. Disturbed and undisturbed rock core samples were collected from these deposits which were tested for moisture content, density and unconfined compressive strength. These deposits are classified as *'extremely weak to very weak'* according to BS-5930. Table 4.7 summarizes the details of these deposits.

Table 4.7 Deposits of Claystone

Borehole No.	Depth (meters)
BH-23	7.5 – 10.0
BH-25	8.2 – 10.0
BH-24	8.4 – 10.0

4.8 SANDSTONE

Deposits of sandstone and friable sandstone were recovered from three boreholes drilled at the site. Disturbed and undisturbed rock core samples were collected from these deposits which were tested for moisture content, density and unconfined compressive strength. These deposits are classified as *'very weak'* according to BS-5930. Table 4.8 summarizes the details of these deposits.

Table 4.8 Deposits of Sandstone

Borehole No.	Depth (meters)
BH-04	13.2 – 14.3
BH-14	22.0 – 30.0
BH-16	24.2 – 40.0

4.9 LIMESTONE

Deposits of limestone was encountered in only one borehole drilled at the site. The rock is classified as 'very poor' based on RQD values which corresponds to NIL. These deposits are classified as *'extremely weak'* according to BS-5930. Table 4.9 summarizes the details of these deposits.

Table 4.9 Deposits of Limestone

Borehole No.	Depth (meters)
BH-18	7.5 – 14.0

4.10 GROUNDWATER CONDITIONS

Groundwater table was encountered at a depth range of 0.76 to 0.91 meters below the existing ground level in four (04) out of total twenty seven (27) boreholes drilled during the time of this investigation. Perched water table was also encountered in twelve (12) borehole, at a depth range of 0.61 to 11.5 meters below the existing ground level. However, this may fluctuate due to seasonal and other environmental variations.

5. ENGINEERING DESIGN CONSIDERATIONS

Foundation type for a structure depends on the expected loads taken by the foundation and the type of soil underlying it. The characteristics of subsurface soil deposits have been discussed in the previous section. As per the information provided by the client, following building types and structures are proposed for construction at the project site:

Table 5.1: Details of proposed building types and foundations

Structure type	Boreholes Covered	Proposed Foundation Type
Stations	BH-01 – BH-12	Shallow or deep foundation
Bridge	BH-13 to BH-16	Deep foundation
Station	BH-17, BH-19 to BH-22	Shallow foundation
Elevated U-Turn	BH18 & BH-23	Shallow or deep foundation
Depot-1	BH-24 & BH-25	Shallow or deep foundation
Depot-2	BH-26 & BH-27	Shallow or deep foundation

Keeping in view the subsoil conditions prevailing at the site and the loads expected to be transferred to the foundations and as per the project specifications, recommendations for both shallow (including isolated and raft foundation) and deep foundations (including cast in-situ drilled pile foundations) are provided. Following sections discusses recommendations for shallow and deep foundations, in detail.

5.1 DESIGN PARAMETERS

Design soil parameters at the site are based on grain size, material type and SPT N-values. The design soil parameters for the profiles used in our analysis are tabulated below:

Table 5.2: Engineering Design Parameters for (BH-01)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.0	1.5	6	Silt	20	0	17.0	3600
2.0	4.0	2.0	10	Sand	0	29	17.0	10000
4.0	5.0	1.0	28	Sand	0	32	18.0	21500
5.0	10.0	5.0	40	Sand	0	35	19.0	27500

Table 5.3: Engineering Design Parameters for (BH-02)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.0	1.5	3	Clay	10	0	16.5	3000
2.0	3.0	1.0	13	Sand	0	29	17.5	13000
3.0	7.0	4.0	24	Sand	0	32	18.0	19500
7.0	10.5	3.5	50	Sand	0	36	19.0	50000
10.5	13.5	3.0	43	Clay	200	0	19.0	50000
13.5	16.5	3.0	50	Sand	0	36	19.0	32500
16.5	20.0	3.5	50	Silt	45	0	19.0	20000

Table 5.4: Engineering Design Parameters for (BH-03)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	3.0	2.5	9	Sand	0	28	17.0	9000
3.0	6.5	2.5	37	Sand	0	35	19.0	26000
6.5	8.5	2.0	27	Silt	20	0	18.0	10000
8.5	10.0	1.5	50	Clay	200	0	18.5	50000

Table 5.5: Engineering Design Parameters for (BH-04)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0	3.0	3.0	13	Sand	0	29	17.5	13000
3.0	13.0	10.0	48	Sand	0	35	19.0	31500
13.0	14.0	1.0	50	Sandstone	0	40	21.0	100000
14.0	17.5	3.5	50	Clay/Silt	200	0	18.5	50000
17.5	20.0	2.5	50	Sand	0	36	19.0	50000

Table 5.6: Engineering Design Parameters for (BH-05)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
2.0	4.0	2.0	23	Sand	0	32	18.0	19000
4.0	10.0	6.0	50	Sand	0	35	19.0	50000

Table 5.7: Engineering Design Parameters for (BH-06)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.0	2.5	1.5	50	Sand	0	35	19.0	32500
2.5	3.5	1.0	50	Silt	65	0	18.5	20000
3.5	6.5	3.0	50	Sand	0	35	19.0	50000
6.5	7.5	1.0	50	Gravel	0	36	19.0	60000
7.5	10.0	2.5	30	Clay	150	0	18.0	45000
10.0	11.5	1.5	50	Sand	0	35	19.0	50000
11.5	13.5	2.0	28	Clay/Silt	125	0	18.5	37500
13.5	16.5	3.0	50	Sand	0	35	19.0	50000
16.5	17.5	1.0	50	Gravel	0	36	19.0	60000
17.5	18.5	1.0	50	Silt	22	0	18.5	20000

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ),	Unit Weight co-related with SPT N	Modulus of Elasticity, E (kN/m^2)
18.5	20.0	1.5	50	Clay	200	0	18.5	50000

Table 5.8: Engineering Design Parameters for (BH-07)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.0	1.5	9	Sand	0	29	17.0	9000
2.0	3.5	1.5	16	Sand	0	30	17.5	15000
3.5	4.5	1.0	26	Silt	58	0	18.0	9600
4.5	6.5	2.0	33	Sand	0	35	18.5	24000
6.5	8.5	2.0	25	Silt	65	0	18.0	9300
8.5	16.5	8.0	50	Sand	0	35	19.0	50000
16.5	20.0	3.5	50	Silt	65	0	18.5	50000

Table 5.9: Engineering Design Parameters for (BH-08)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.0	1.5	0.5	30	Sand	0	34	18.5	22500
1.5	2.5	1.0	35	Silt	0	0	18.5	17500
2.5	5.5	3.0	50	Sand	0	35	19.0	50000
5.5	8.5	3.0	26	Silt	65	0	18.0	9600
8.5	10.0	1.5	35	Sand	0	35	18.5	50000

Table 5.10: Engineering Design Parameters for (BH-09)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0	1.5	2.5	35	Sand	0	35	18.0	25000
1.5	2.5	1.0	14	Sand	0	29	17.5	14000

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ),	Unit Weight co-related with SPT N	Modulus of Elasticity, E (kN/m^2)
2.5	3.5	1.0	20	Silt	0	20	18.0	7800
3.5	4.5	1.0	44	Silt	0	23	18.0	15000
4.5	6.5	2.0	50	Sand	0	35	19.0	50000
6.5	8.5	2.0	18	Silt	62	0	18.0	7200
8.5	16.0	7.5	50	Sand	0	35	19.0	50000
16.0	20.0	4.0	49	Silt	58	0	18.5	20000

Table 5.11: Engineering Design Parameters for (BH-10)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.5	5.5	4.0	46	Silt	30	0	18.5	15600
5.5	8.0	2.5	50	Sand	0	35	19.0	50000
8.0	10.0	2.0	42	Clay/Silt	150	0	18.5	45000

Table 5.12: Engineering Design Parameters for (BH-11)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.0	2.0	1.0	3	Sand	0	26	16.5	3000
2.0	3.0	1.0	10	Sand	0	28	17.0	10000
3.0	4.0	1.0	50	Sand	0	35	19.0	50000
4.0	4.5	0.5	14	Sand	0	29	17.5	14000
4.5.	6.5	2.0	14	Clayey Silt	75	0	17.5	6000
6.5	10.0	3.5	50	Sand	0	35	19.0	50000

Table 5.13: Engineering Design Parameters for (BH-12)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.5	5.0	3.5	21	Sand	0	32	18.0	18000
5.0	6.5	1.5	45	Sand	0	35	19.0	30000
6.5	7.0	0.5	1	Sand	0	25	16.0	3000
7.0	8.0	1.0	21	Silt	62	0	18.0	8100
8.0	9.5	1.5	29	Sand	0	33	18.5	22000
9.5	11.5	2.0	27	Silt	64	0	18.0	9900
11.5	14.5	3.0	50	Sand	0	35	19.0	50000
14.5	16.5	2.0	50	Silt	64	0	18.5	20000
16.5	18.0	1.5	50	Sand	0	35	19.0	50000
18.0	20.0	2.0	50	Clay	150	0	18.5	50000

Table 5.14: Engineering Design Parameters for (BH-13 to BH-16)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	3.0	2.5	05	Sand	0	27	16.5	5000
3.0	6.0	3.0	02	Silt	15	0	16.0	2400
6.0	7.0	1.0	24	Sand	0	32	18.0	19500
7.0	8.0	1.0	02	Silt	15	0	16.0	2400
8.0	10.0	2.0	08	Silt	40	0	17.5	4200
10.0	13.0	3.0	36	Sand	0	35	18.5	25500
13.0	20.0	7.0	48	Silt	63	0	18.0	20000
20.0	25.0	5.0	50	Sand	0	36	18.5	50000
25.0	30.0	5.0	50	Sandstone	50	40	20.0	100000

Table 5.15: Engineering Design Parameters for (BH-17)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.5	2.5	21	Sand	0	33	18.0	18000
2.5	5.5	3.0	3	Clay	15	0	16.5	4500
5.5	11.0	5.5	3	Silt	15	0	16.5	2700
11.0	11.5	0.5	31	Silt	55	0	18.0	11100
11.5	12.0	0.5	50	Sand	0	35	19.0	50000

Table 5.16: Engineering Design Parameters for (BH-18)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	4.5	4.0	5	Silt	20	0	17.0	3300
4.5	7.5	3.0	2	Clay	10	0	16.5	3000
7.5	14.0	6.5	50	Limestone	0	40	21.0	100000
14.0	18.0	4.0	50	Mudstone	100	40	21.0	100000

Table 5.17: Engineering Design Parameters for (BH-19)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.5	2.0	50	Silt	65	0	18.5	20000
2.5	3.5	1.0	50	Sand	0	35	19.0	50000
3.5	4.5	1.0	50	Gravel	0	36	19.0	60000
4.5	10.0	5.5	50	Sand	0	35	19.0	50000

Table 5.18: Engineering Design Parameters for (BH-20)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	1.0	0.5	13	Sand	0	30	17.5	14000
1.0	5.5	4.5	50	Sand	0	35	19.0	50000
5.5	6.5	1.0	50	Silt	43	0	18.5	20000
6.5	12.0	5.5	50	Sand	0	35	19.0	50000

Table 5.19: Engineering Design Parameters for (BH-21)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.0	1.5	1.5	7	Silt	0	0	17.0	3900
1.5	2.5	1.0	10	Clay	60	0	17.5	18000
2.5	5.0	2.5	45	Silt	55	0	18.5	15300
5.0	10.0	5.0	47	Sand	0	35	19.0	31000

Table 5.20: Engineering Design Parameters for (BH-22)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
1.0	1.5	0.5	26	Sand	0	33	18.0	20500
1.5	2.5	1.0	07	Sand	0	28	17.0	7000
2.5	3.5	1.0	50	Clay	200	0	18.0	50000
3.5	7.0	3.5	50	Sand	0	36	19.0	50000
7.0	10.0	3.0	50	Mudstone	50	40	20.0	100000

Table 5.21: Engineering Design Parameters for (BH-23)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	1.5	1.0	9	Sand	0	29	17.0	9000
1.5	2.5	1.0	28	Silt	25	0	18.0	10200
2.5	7.5	5.0	50	Clay/Silt	200	0	18.5	50000
7.5	10.0	2.5	50	Claystone	50	40	21.0	100000
10.0	14.0	4.0	50	Mudstone	100	40	21.0	150000

Table 5.22: Engineering Design Parameters for (BH-24 & BH-25)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	8.0	7.5	46	Sand	0	35	19.0	30500
8.0	10.0	2.0	50	Claystone	100	40	21.0	150000

Table 5.23: Engineering Design Parameters for (BH-26 & BH-27)

Layer Depth Below EGL (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.5	2.0	1.5	3	Sand	0	26	16.5	3000
2.0	4.0	2.0	20	Sand	0	31	18.0	17500
4.0	5.0	1.0	3	Clay/Silt	15	0	16.5	2700
5.0	6.0	1.0	11	Sand	0	28	17.5	11000
6.0	9.0	3.0	3	Clay/Silt	15	0	16.5	2700
9.0	11.0	2.0	21	Sand	0	31	18.0	18000
11.0	12.0	1.0	50	Sand	0	36	19.0	50000

5.2 DESIGN CRITERIA FOR SHALLOW FOUNDATIONS

A suitable shallow foundation for any structure must satisfy two basic independent criteria with respect to the underlying foundation soils. First, the foundation must have an

adequate factor of safety against exceeding the bearing capacity of the foundation soils. Second the vertical movements of the foundation due to settlement or swelling of the foundation soils must be within tolerable limits for the structure.

Dynamically loaded foundations, such as those supporting vibrating machinery, must satisfy additional criteria as follows:

- vibrations transmitted to the foundation soils must not cause excessive settlement of the structures or its surroundings;
- vibrations of the dynamically loaded structure, and its surroundings, must not interfere with planned operations and adjacent structures.

The foundation bearing pressures should be limited so that settlements do not exceed tolerable limits for the structures.

5.3 ALLOWABLE BEARING PRESSURES FOR SHALLOW FOUNDATION

The allowable bearing pressure for shallow footings i.e. isolated and raft foundations supported on natural soils/rocks at the site will be limited either by the settlement tolerance of individual structures, or by the bearing capacity of the soil, depending on the foundation width and depth of influence. Typically, for shallow isolated footings, the bearing pressure should be limited so that the total foundation settlement does not exceed 25 mm, with differential settlements of about 50 percent of the total settlement, or so that the bearing capacity is not exceeded, whichever is the lower of the two values.

The ratio of differential to total settlements for raft foundations on sand is typically half that of an isolated footing (Terzaghi, Peck and Mesri, 1996). Consequently, the amount of settlement that a raft foundation can tolerate is twice that of an isolated foundation, usually 50 mm. However, the actual settlement tolerance of various structures should be defined by the structural engineer.

We estimated the allowable bearing pressure of planned isolated and raft foundations as the lower of the two values calculated based on settlement and shear criteria. Table 5.24 to 5.40 gives the allowable bearing pressures for shallow foundations at a depth of 1.5 – 2.0 meters from existing ground level.

Table 5.24a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-01	1.5	1.0	140.0
		1.5	160.0
		2.0	150.0
		2.5	135.0
		3.0	125.0
	2.0	1.0	335.0
		1.5	335.0
		2.0	335.0
		2.5	285.0
		3.0	245.0

Table 5.24b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-01	1.5	6.0	230.0
		8.0	235.0
		10.0	220.0
		12.0	200.0
		15.0	175.0
	2.0	6.0	365.0
		8.0	355.0
		10.0	325.0
		12.0	290.0
		15.0	245.0

Table 5.25a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-02	2.0	1.0	335.0
		1.5	365.0
		2.0	350.0
		2.5	270.0
		3.0	275.0

Table 5.25b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-02	2.0	6.0	465.0
		8.0	295.0
		10.0	245.0
		12.0	200.0
		15.0	165.0

Table 5.26a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-03	1.5	1.0	225.0
		1.5	235.0
		2.0	265.0
		2.5	235.0
		3.0	200.0
	2.0	1.0	300.0
		1.5	365.0
		2.0	395.0
		2.5	275.0
		3.0	210.0

Table 5.26b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-03	1.5	6.0	255.0
		8.0	190.0
		10.0	155.0
		12.0	130.0
		15.0	115.0
	2.0	6.0	270.0
		8.0	200.0
		10.0	160.0
		12.0	135.0
		15.0	155.0

Table 5.27a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-04	1.5	1.0	320.0
		1.5	340.0
		2.0	380.0
		2.5	360.0
		3.0	305.0
	2.0	1.0	425.0
		1.5	495.0
		2.0	500.0*
		2.5	415.0
		3.0	340.0

Table 5.27b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-04	1.5	6.0	405.0
		8.0	300.0
		10.0	275.0
		12.0	220.0
		15.0	180.0
	2.0	6.0	435.0
		8.0	340.0
		10.0	285.0
		12.0	230.0
		15.0	190.0

Table 5.28a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-05	1.5	1.0	365.0
		1.5	390.0
		2.0	400.0
		2.5	445.0
		3.0	450.0
	2.0	1.0	480.0
		1.5	490.0
		2.0	500.0*
		2.5	500.0*
		3.0	475.0

Table 5.28b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-05	1.5	6.0	500.0*
		8.0	445.0
		10.0	360.0
		12.0	305.0
		15.0	245.0
	2.0	6.0	500.0*
		8.0	475.0
		10.0	380.0
		12.0	315.0
		15.0	255.0

Table 5.29a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-06	1.5	1.0	500.0*
		1.5	370.0
		2.0	275.0
		2.5	225.0
		3.0	195.0
	2.0	1.0	470.0
		1.5	320.0
		2.0	250.0
		2.5	215.0
		3.0	185.0

Table 5.29b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-06	1.5	6.0	300.0
		8.0	210.0
		10.0	160.0
		12.0	135.0
		15.0	115.0
	2.0	6.0	295.0
		8.0	200.0
		10.0	155.0
		12.0	135.0
		15.0	115.0

Table 5.30a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-07	1.5	1.0	266.0
		1.5	290.0
		2.0	220.0
		2.5	175.0
		3.0	150.0
	2.0	1.0	350.0
		1.5	315.0
		2.0	240.0
		2.5	195.0
		3.0	155.0

Table 5.30b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-07	1.5	6.0	240.0
		8.0	200.0
		10.0	120.0
		12.0	145.0
		15.0	120.0
	2.0	6.0	255.0
		8.0	205.0
		10.0	175.0
		12.0	150.0
		15.0	125.0

Table 5.31a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-08	1.5	1.0	250.0
		1.5	195.0
		2.0	170.0
		2.5	130.0
		3.0	105.0
	2.0	1.0	500.0*
		1.5	500.0*
		2.0	360.0
		2.5	230.0
		3.0	175.0

Table 5.31b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-08	1.5	6.0	190.0
		8.0	135.0
		10.0	115.0
		12.0	105.0
		15.0	90.0
	2.0	6.0	245.0
		8.0	170.0
		10.0	145.0
		12.0	125.0
		15.0	110.0

Table 5.32a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-09	1.5	1.0	250.0
		1.5	230.0
		2.0	185.0
		2.5	165.0
		3.0	160.0
	2.0	1.0	230.0
		1.5	190.0
		2.0	180.0
		2.5	175.0
		3.0	175.0

Table 5.32b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-09	1.5	6.0	355.0
		8.0	280.0
		10.0	230.0
		12.0	185.0
		15.0	160.0
	2.0	6.0	380.0
		8.0	290.0
		10.0	235.0
		12.0	190.0
		15.0	165.0

Table 5.33a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-10	1.5	1.0	170.0
		1.5	170.0
		2.0	175.0
		2.5	180.0
		3.0	185.0
	2.0	1.0	210.0
		1.5	215.0
		2.0	225.0
		2.5	225.0
		3.0	225.0

Table 5.33b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-10	1.5	6.0	390.0
		8.0	275.0
		10.0	215.0
		12.0	180.0
		15.0	145.0
	2.0	6.0	400.0
		8.0	285.0
		10.0	225.0
		12.0	185.0
		15.0	150.0

Table 5.34a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-11	2.0	1.0	295.0
		1.5	365.0
		2.0	330.0
		2.5	230.0
		3.0	190.0

Table 5.34b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-11	2.0	6.0	300.0
		8.0	235.0
		10.0	195.0
		12.0	170.0
		15.0	145.0

Table 5.35a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-19	1.5	1.0	375.0
		1.5	290.0
		2.0	240.0
		2.5	205.0
		3.0	185.0
	2.0	1.0	500.0*
		1.5	500.0*
		2.0	500*.0
		2.5	421.0
		3.0	354.0

Table 5.35b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-19	1.5	6.0	390.0
		8.0	305.0
		10.0	255.0
		12.0	235.0
		15.0	220.0
	2.0	6.0	360.0
		8.0	420.0
		10.0	345.0
		12.0	315.0
		15.0	285.0

Table 5.36a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-20	1.5	1.0	500.0*
		1.5	500.0*
		2.0	500.0*
		2.5	500.0*
		3.0	500.0*
	2.0	1.0	500.0*
		1.5	500.0*
		2.0	500.0*
		2.5	500.0*
		3.0	500.0*

Table 5.36b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-20	1.5	6.0	500.0*
		8.0	490.0
		10.0	390.0
		12.0	320.0
		15.0	255.0
	2.0	6.0	500.0*
		8.0	500.0*
		10.0	400.0
		12.0	330.0
		15.0	260.0

Table 5.37a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-21	1.5	1.0	150.0
		1.5	95.0
		2.0	75.0
		2.5	60.0
		3.0	50.0
	2.0	1.0	210.0
		1.5	130.0
		2.0	100.0
		2.5	85.0
		3.0	75.0

Table 5.37b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-21	1.5	6.0	115.0
		8.0	105.0
		10.0	95.0
		12.0	90.0
		15.0	80.0
	2.0	6.0	155.0
		8.0	135.0
		10.0	125.0
		12.0	115.0
		15.0	100.0

Table 5.38a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-22	1.5	1.0	225.0
		1.5	390.0
		2.0	315.0
		2.5	265.0
		3.0	240.0
	2.0	1.0	410.0
		1.5	290.0
		2.0	240.0
		2.5	200.0
		3.0	195.0

Table 5.38b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-22	1.5	6.0	445.0
		8.0	385.0
		10.0	335.0
		12.0	300.0
		15.0	260.0
	2.0	6.0	460.0
		8.0	390.0
		10.0	340.0
		12.0	300.0
		15.0	260.0

Table 5.39a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-23	1.5	1.0	485.0
		1.5	290.0
		2.0	210.0
		2.5	185.0
		3.0	120.0
	2.0	1.0	490.0
		1.5	300.0
		2.0	210.0
		2.5	155.0
		3.0	135.0

Table 5.39b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-23	1.5	6.0	250.0
		8.0	195.0
		10.0	175.0
		12.0	155.0
		15.0	135.0
	2.0	6.0	235.0
		8.0	190.0
		10.0	165.0
		12.0	150.0
		15.0	135.0

Table 5.40a: Net Allowable Bearing Pressures for Isolated Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Isolated Foundation (kPa)
BH-24 & BH-25	1.5	1.0	365.0
		1.5	395.0
		2.0	445.0
		2.5	500.0*
		3.0	490.0
	2.0	1.0	485.0
		1.5	500.0*
		2.0	500.0*
		2.5	500.0*
		3.0	500.0*

Table 5.40b: Net Allowable Bearing Pressures for Raft Foundations

Location	Minimum Embedment below EGL (meter)	Width of foundation (meter)	Raft Foundation (kPa)
BH-24 & BH-25	1.5	6.0	500.0*
		8.0	500.0*
		10.0	500.0*
		12.0	500.0*
		15.0	500.0*
	2.0	6.0	500.0*
		8.0	500.0*
		10.0	500.0*
		12.0	500.0*
		15.0	500.0*

5.4 DEEP FOUNDATIONS - ALLOWABLE PILE CAPACITIES

The ultimate compressive capacity, Q, for a given bored concrete pile penetration is taken as the sum of the skin friction on the pile wall, Qs, and the end bearing on the pile tip, Qp, so that:

$$Q = Q_s + Q_p = \Sigma f A_s + q A_p$$

Where A_s and A_p represent, respectively, the embedded surface and pile end area; f and q represent, respectively, the unit skin friction and unit end bearing. When computing ultimate tensile capacity, the end bearing term in the above equation is neglected. Therefore, the value of the ultimate tensile capacity is the same value as the ultimate compression capacity due to skin friction Qs.

The allowable pile capacities have been calculated following shear strength determination, through in-situ field and laboratory test results of collected soil samples. *Table 5.41* gives the allowable pile capacities for the proposed borehole locations.

Table 5.41: Allowable Pile Capacities

Borehole No.	Diameter (mm)	Length of Pile below EGL (m)	Tension (kN)	Compression (kN)
BH-12	760	13.0	375	1867
		17.0	681	2493
	1000	13.0	494	3076
		17.0	896	4032
	1200	13.0	592	4312
		17.0	1076	5592
BH-13, BH-14, BH-15 & BH-16	760	20.0	714	1626
		25.0	939	2234
	1000	20.0	940	2518
		25.0	1236	3477

Borehole No.	Diameter (mm)	Length of Pile below EGL (m)	Tension (kN)	Compression (kN)
BH-13, BH-14, BH-15 & BH-16	1200	20.0	1128	3400
		25.0	1483	4710
BH-17	760	12.0	184	855
	1000	12.0	242	1404
	1200	12.0	291	1964
BH-18	760	15.0	2992	4378
		18.0	4246	5632
	1000	15.0	3936	6336
		18.0	5586	7986
	1200	15.0	4724	8179
		18.0	6704	10159
BH-23	760	10.0	1303	2664
		12.0	2199	3560
	1000	10.0	1714	3075
		12.0	2893	4254
	1200	12.0	2057	4414
		12.0	3471	5828
BH-26 & BH-27	760	12.0	152	937
	1000	12.0	200	1558
	1200	12.0	240	2196

The design approach followed is based on FOS and as per this design approach, the settlement criteria that has been suggested by STS (i.e. Net settlement not to exceed 1% of the pile diameter at working load and total penetration of the base not to exceed 10% of the pile diameter at test load) shall be fulfilled. Moreover, these pile capacities shall be verified by full scale pile load tests where test pile should be loaded to 2.0 to 2.5 times the Specified Working Load (SWL) and the working pile should be loaded to 1.5 to 2.0 times the Specified Working Load (SWL). The calculations for allowable pile capacities of each location for 760, 1000 mm and 1200 mm diameter bored cast in-situ piles are presented in appendix F of this report.

5.5 RECOMMENDED DRILLING METHOD AND CONFIRMATORY TESTING

The recommended drilling method for the construction of bored cast in-situ piles is straight rotary. Tentative pile capacity values given in table 5.41 have been computed by static formulae which suffer from limitations. As such capacity values shall be verified by full scale load tests under the guidance of geotechnical engineer. Pile capacity shall be suitably adjusted if warranted by results of load tests. This report will be valid only if requirement of pile load tests is fulfilled.

5.6 PILE CONSTRUCTION

Allowable pile capacities have been derived from combination of end bearing and skin friction components. It is, therefore, essential to adopt the following construction methodology to satisfy following requirements:

1. Excessive disturbance to sub-surface along shaft and pile tip shall be avoided during the course of drilling.
2. The bottom of pile shall be cleaned of all loose materials which may accumulate during the course of drilling.

It is understood that subsurface materials will be carefully examined during pilling and it shall be ensured that all piles are placed in proper stratum. This exercise will serve as safeguard against variations in quality and level of occurrence of rock or dense stratum. Pile concreting shall be undertaken only when above conditions are fulfilled.

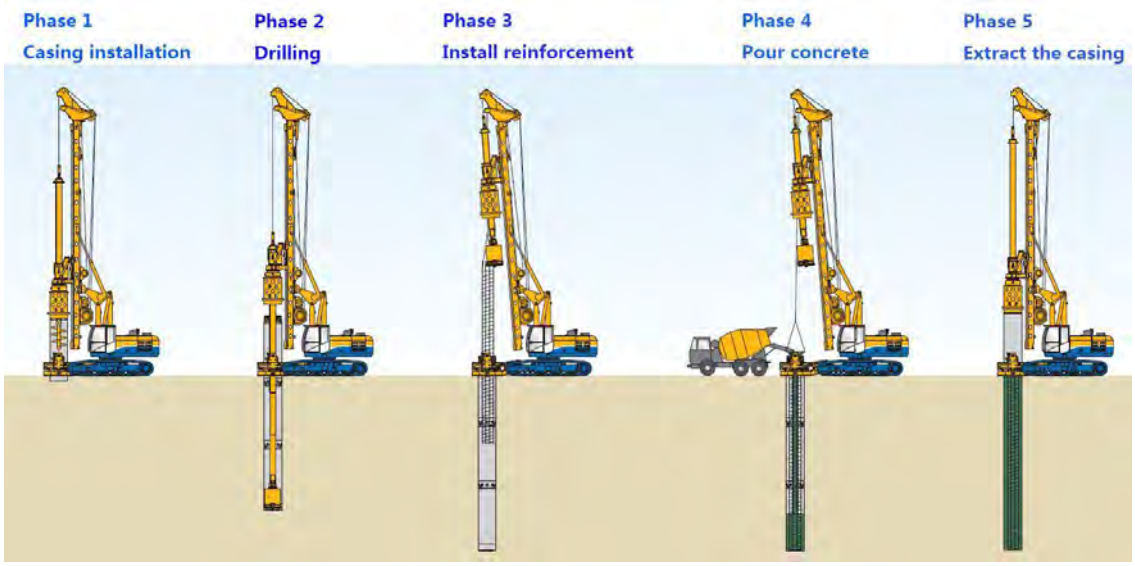


Figure 5.1: Construction of cast in situ piles by straight rotary

5.7 EARTH RETAINING STRUCTURE

All measures shall be taken to provide safety to adjacent structures before excavation. Properly designed earth retaining structure such as secant pile wall or contiguous pile wall depending upon the ground water situation, must be constructed prior to deep excavation. Earth pressure parameters as required for the design of structure to retain the excavation, are given in *Table 5.42 – 5.47.*

Table 5.42: Earth Pressure Parameters for (BH-02)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
0.5	2.0	Clay	10	0	1.0	1.0
2.0	3.0	Sand	0	29	0.347	2.882
3.0	7.0	Sand	0	32	0.307	3.255
7.0	10.5	Sand	0	36	0.260	3.853
10.5	13.5	Clay	200	0	1.0	1.0
13.5	16.5	Sand	0	36	0.260	3.853
16.5	20.0	Silt	45	0	1.0	1.0

Table 5.43: Earth Pressure Parameters for (BH-04)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
0	3.0	Sand	0	29	0.347	2.882
3.0	13.0	Sand	0	35	0.271	3.691
13.0	14.0	Sandstone	50	40	0.217	4.600
14.0	17.5	Clay/Silt	200	0	1.0	1.0
17.5	20.0	Sand	0	36	0.260	3.853

Table 5.44: Earth Pressure Parameters for (BH-06)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
1.0	2.5	Sand	0	35	0.271	3.691
2.5	3.5	Silt	65	0	1.0	1.0
3.5	6.5	Sand	0	35	0.271	3.691
6.5	7.5	Gravel	0	36	0.260	3.853
7.5	10.0	Clay	150	0	1.0	1.0
10.0	11.5	Sand	0	35	0.271	3.691
11.5	13.5	Clay/Silt	125	0	1.0	1.0
13.5	16.5	Sand	0	35	0.271	3.691
16.5	17.5	Gravel	0	36	0.260	3.853
17.5	18.5	Silt	22	0	1.0	1.0
18.5	20.0	Clay	200	0	1.0	1.0

Table 5.45: Earth Pressure Parameters for (BH-07)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
0.5	2.0	Sand	0	29	0.347	2.882
2.0	3.5	Sand	0	30	0.333	3.000
3.5	4.5	Silt	58	0	1.0	1.0
4.5	6.5	Sand	0	35	0.271	3.691
6.5	8.5	Silt	65	0	1.0	1.0
8.5	16.5	Sand	0	35	0.271	3.691
16.5	20.0	Silt	65	0	1.0	1.0

Table 5.46: Earth Pressure Parameters for (BH-09)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
0	1.5	Sand	0	35	0.271	3.691
1.5	2.5	Sand	0	29	0.347	2.882
2.5	3.5	Silt	0	20	0.490	2.040
3.5	4.5	Silt	0	23	0.438	2.283
4.5	6.5	Sand	0	35	0.271	3.691
6.5	8.5	Silt	62	0	1.0	1.0
8.5	16.0	Sand	0	35	0.271	2.283
16.0	20.0	Silt	58	0	1.0	1.0

Table 5.47: Earth Pressure Parameters for (BH-12)

Layer Depth Below EGL (m)		Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Ka (Coefficient of active earth pressure)	Kp (Coefficient of passive earth pressure)
Top	Bottom					
1.5	5.0	Sand	0	32	0.307	3.255
5.0	6.5	Sand	0	35	0.271	3.691
6.5	7.0	Sand	0	25	0.406	2.464
7.0	8.0	Silt	62	0	1.0	1.0
8.0	9.5	Sand	0	33	0.295	3.393
9.5	11.5	Silt	64	0	1.0	1.0
11.5	14.5	Sand	0	35	0.271	3.691
14.5	16.5	Silt	64	0	1.0	1.0
16.5	18.0	Sand	0	35	0.271	3.691
18.0	20.0	Clay	150	0	1.0	1.0

5.8 LIQUEFACTION POTENTIAL OF SOIL

The potential for liquefaction at this project site was evaluated using Peysanj software. This program is based on the most recent publications of the NCEER Workshop using Seed and Idriss Implementation and Ambraseys MSF method. The method evaluates liquefaction potential based on soil type and density, groundwater conditions, peak surface acceleration, magnitude of the design earthquake.

The method is used to compare the cyclic shear stresses indicated during the design earthquake, with those that would be required to cause liquefaction to determine whether any zone exists within the soil where liquefaction may be expected.

A peak ground acceleration of 0.20g was evaluated based on PBC Seismic provision 2007 for design, and has been adopted for the current study. We based our liquefaction analyses for an earthquake magnitude of M = 6.6.

Using the design parameters and procedures discussed above, the factors of safety against liquefaction for all twenty seven (27) boreholes were calculated. The factor of safety against liquefaction is observed as greater than 1.0 for majority of the boreholes. However, in four (04) borehole locations (**BH-13 to BH-16**) the subsurface deposits are

susceptible to liquefaction up to max. 8 meters depth below the existing site grade. Therefore, at these borehole locations either soil improvement is performed or deep foundations shall be installed to mitigate the effects of liquefaction. The results of liquefaction analysis is provided in appendix G of the report.

5.9 SOIL IMPROVEMENT

As discussed above, the subsurface strata encountered at nine borehole locations (**BH-12, BH-17, BH-18, BH-26 and BH-27**) shows very loose fine to medium grained silty sand and very soft to soft clayey silt up to max. 10.5 meters below the existing ground level. Hence, the allowable bearing capacities are on very lower side for shallow footings. Therefore, to densify the existing soil and increase the bearing capacities, ***soil improvement*** may be required.

The most effective method for soil improvement in this type of soil is installation of *Stone Columns*. The following sections describe the process of installation of stone columns in detail.

5.9.1 STONE COLUMNS

Stone Columns is a ground improvement technique to improve the load bearing capacity and reduce the settlement of the soil. The stone column consists of crushed coarse aggregates of various sizes. The ratio in which the stones of different sizes will be mixed is decided by design criteria. The aforementioned crushed aggregates in the definite proportion are to be placed into the soil at regular intervals throughout the area of the land where the soil bearing capacity is to be improved. This is done either by using the dry or the wet top feed vibrators which are forced into the ground. The aggregates are then allowed to take the place of the displaced soil which exerts a pressure on the surrounding soil, hence helping to improve the soil's load-bearing capacity.

The vibrating probe breaks down the pores of the surrounding soil, thereby densifying the soil. The crushed aggregates or the gravel that is poured in takes the place of the soil and keeps up the pressure on the soil that was created by the vibrating probe.

These columns are made across the area to be built on in a grid pattern at regular intervals.

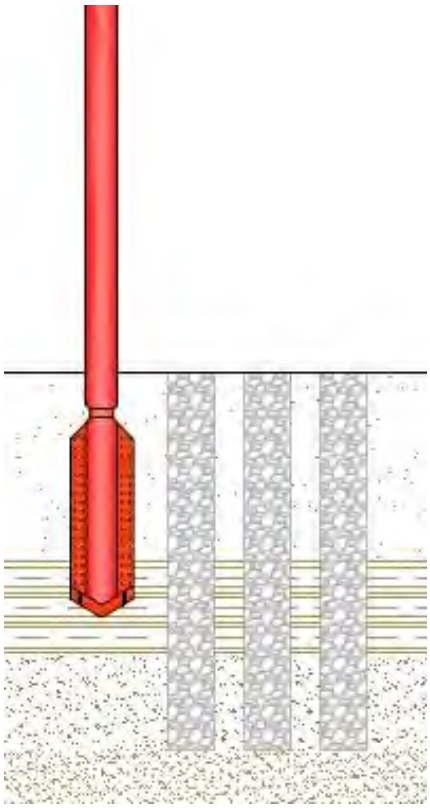


Figure. 5.2 Construction of densified stone column

Figure. 5.3 Grid pattern for soil improvement by stone column

5.9.2 FIELD TESTING FOLLOWING SOIL IMPROVEMENT

If soil improvement is undertaken at the site then confirmatory field testing should be carried out to determine the extent of soil improvement. This can be carried out by either or all of the following in-situ tests:

- Standard Penetration Test (SPT)
- Plate Load Test
- Zone load Test

5.10 ALLOWABLE BEARING PRESSURES FOR SHALLOW FOUNDATION AFTER SOIL IMPROVEMENT

Table 5.48 gives the tentative net allowable bearing pressure for shallow foundations expected after soil improvement at a depth of 1.0 – 1.5 meters from final grade level.

Table 5.48 Tentative Net Allowable Bearing Pressures (with soil improvement)

Minimum Embedment below Final Grade Level (meter)	Isolated Foundations (kPa)
1.0 – 1.5	100.0

The bearing capacity values provided above are tentative and should be verified by a detailed and comprehensive stone column design. However, such design is beyond the scope of this investigation report, and should be performed by a qualified soil improvement contractor.

5.11 SOIL PROFILE TYPE (ACCORDING TO UBC-97)

Chapter 16, Division V, Section 1636 of UBC-97 deals with the determination of Soil Profile Types. Design practice involves using seismic parameters of zone 2B for the area under consideration.

5.11.1 SEISMIC ZONE FACTOR

Table 16-I of UBC-97 defines the seismic zone factor to be used in choosing seismic coefficients for a location. The seismic zone factor **"Z"** will be taken as 0.20.

5.11.2 SOIL PROFILE TYPE

Table 16-J of UBC-97 defines the soil profile types to be used for determining seismic coefficients. Based on the field data obtained from sub-soil exploration, the soil profile will be taken as **"S_C"** & **"S_D"**.

5.11.3 SEISMIC COEFFICIENTS

Seismic coefficients are as under:

Table 5.49 Seismic Coefficients

Borehole No.	Soil Profile	C_a	C_V
BH-04 to BH-06, BH-08, BH-10, BH-19 to BH-25	**S_C**	0.24	0.32
BH-01 to BH-03, BH-07 & BH-09, BH-11 to BH-18, BH-26 & BH-27	**S_D**	0.28	0.40

5.12 TYPE OF CEMENT

Tests on soil and water samples obtained from the boreholes indicate 'negligible to moderate' exposure for sulphate and chloride. Under these conditions it is recommended to use *Ordinary Portland Cement with slag or* any other appropriate cement replacement material *like GGBFS, fly ash, micro silica, etc.* for all underground concrete works below water table. However, for underground construction above water table, *Ordinary Portland Cement (OPC)* shall be used.

5.13 DISCUSSION ON TEST PITS AND EARTH WORK TESTS

Seventeen (17) test pits were excavated at site up to the maximum 2.0 meters depth at the locations designated by the clients. The strata encountered in the test pits were mainly gravel, silt and sand. Groundwater was encountered in two of the test pits at a depth of 1.1 – 1.2 meters below existing site grade. Bulk samples were collected from the test pits and transported to laboratory for further testing. Field density tests were carried out in all the test pits at the site. The detail of test pits is presented below:

Table 5.50 Summary of test pits

Test Location	Test/Sample Depth (m)	Soil Classification	Maximum Dry Density (gm/m^3)	Percentage Compaction (%)	CBR @ 95% Max Dry Density (%)
TP-01	0.25	GP-GM	2.34	99.63	58.0
	1.00	ML	1.84	93.84	10.5
TP-02	1.50	SM	1.95	80.85	14.2
TP-03	1.60	ML	1.74	93.48	7.9
TP-04	0.35	GW-GM	2.31	96.95	44.5
	1.20	ML	1.72	86.06	8.2
TP-05	0.25	GP-GM	2.32	94.45	55.0
	1.20	ML	1.68	90.18	4.3
TP-06	0.55	SM	1.95	99.33	11.5
TP-7	0.30	GP-GM	2.32	97.02	56.0
	1.20	SM	2.05	67.72	12.80
TP-11	0.25	GW-GM	2.35	87.23	50.1
	0.65	SP-SM	2.15	83.36	18.0
TP-15	0.75	SM	2.22	74.28	15.0
TP-16	0.70	GP	2.26	78.52	12.8
TP-17	0.55	SP-SM	2.11	75.00	13.0
TP-18	0.75	SM	2.14	75.35	13.2

The subsurface deposits from the test pits mainly consists of AASHTO class A-1-a, A-2-4 and A-4. These deposits are classified as excellent to fair to be used as subgrade

material. The field percentage compaction values at the site are in the range of 74.28% to 99.63% of Modified *AASHTO* dry density, however, the field percentage compaction values should be kept, as a minimum, at 95% of Modified *AASHTO* dry density.

Table 5.51 Minimum CBR value

Soil Type	**Minimum CBR @ 95% Max Dry Density (%)**
Gravel	12.8
Sand	11.5
Silt	4.3

6. CONCLUSIONS

Geotechnical Investigation for Bus Rapid Transit System (BRTS), Yellow Line (from Dawood Chowrangi to Numaish Chorangi and Regal Chowk via 8000 Road, Korangi Road, Karachi, was carried out in September to October, 2019. Scope of field work included drilling of twenty seven (27) boreholes up to the maximum 40 meters depth below the existing ground level. Seventeen (17) test pits were also excavated up to maximum 2.0 meters depth. Soil, rock and ground water samples were collected during the field investigation. Laboratory testing on these samples has been carried out in the lab and includes determination of index properties through grain-size analysis, Atterberg limits, natural moisture content, unconfined compressive strength, consolidation, direct shear, organic matter, density etc. Chemical characteristics of soil and water samples have also been assessed through determination of total dissolved solids, sulphate content, chloride content and pH.

Keeping in view the subsoil conditions prevailing at the site, type of structures and the loads expected to be transferred to the foundations, shallow foundations have been recommended as the main foundation system for stations. However, recommendations for deep foundations have also been presented for bridge locations and liquefiable borehole locations. The exposure of underground concrete to aggressive chemicals is found to be *'negligible to moderate'* for sulphates and chlorides. Therefore, it is recommended to use *Ordinary Portland Cement with slag or* any other appropriate cement replacement material *like GGBFS, fly ash, micro silica, etc.* for all underground concrete works below water table. However, for underground construction above water table, *Ordinary Portland Cement (OPC)* shall be used.

Appendix A

Borehole Locations Plan

Fig. A-1

Sheet 1 of 3

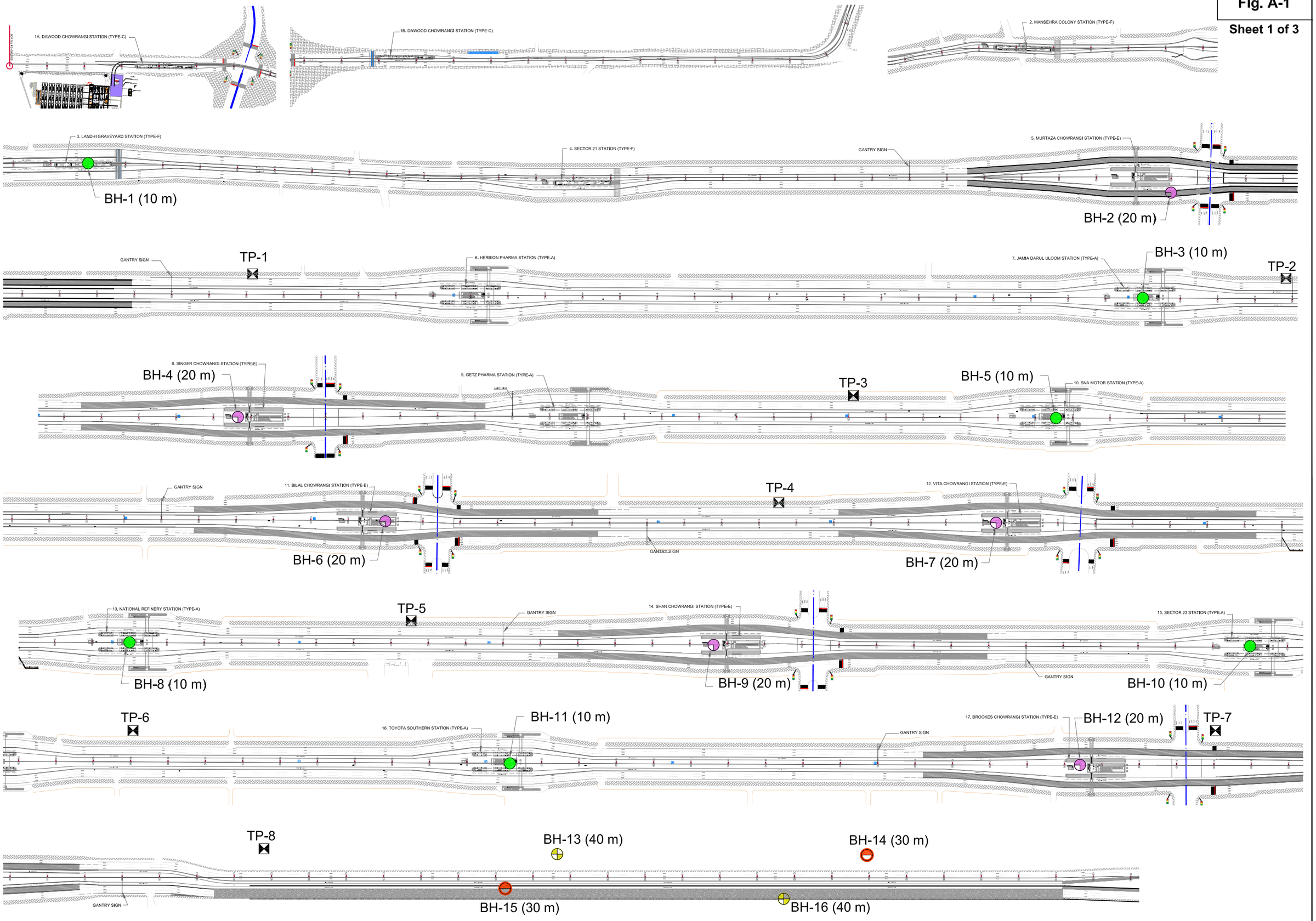
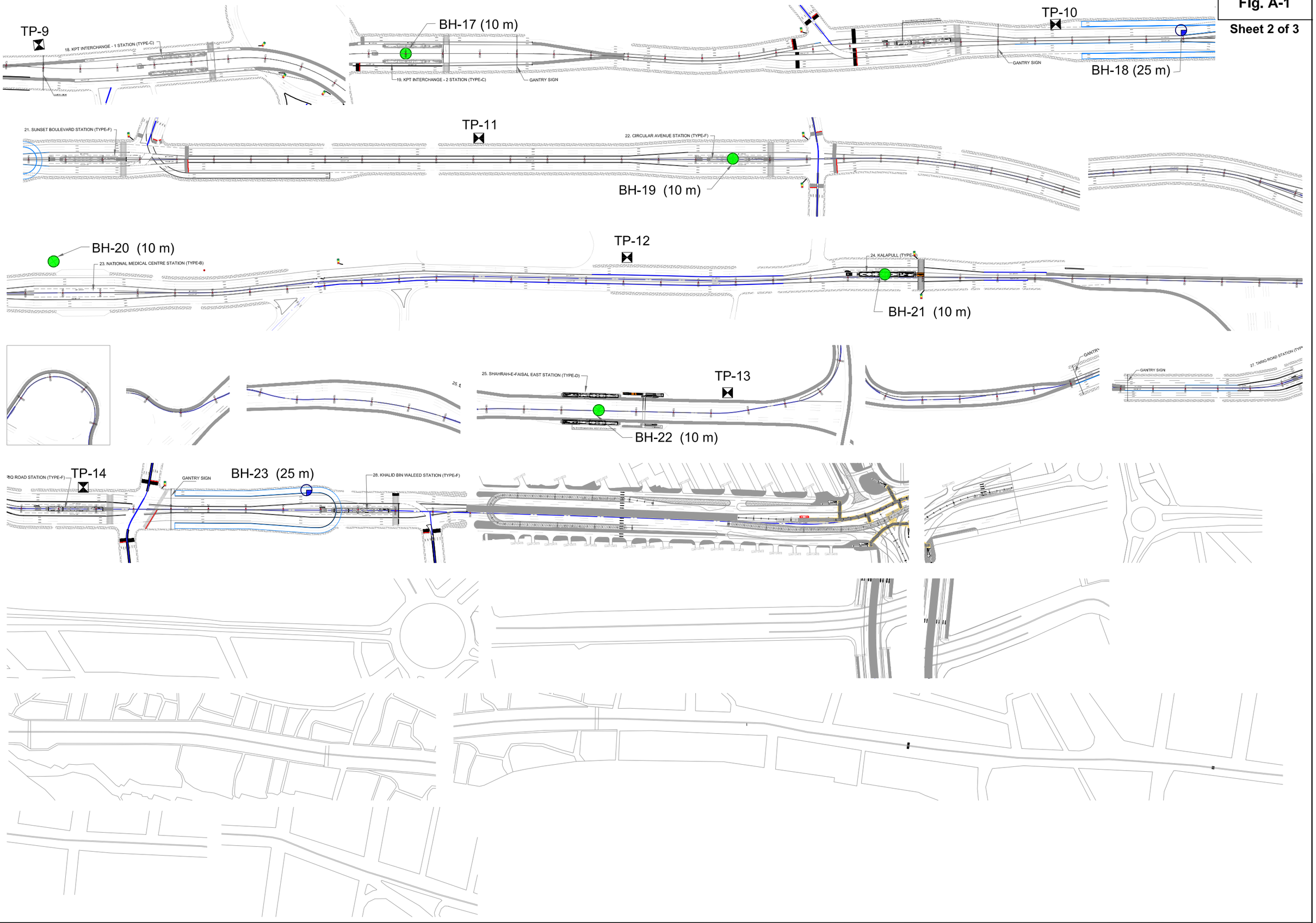
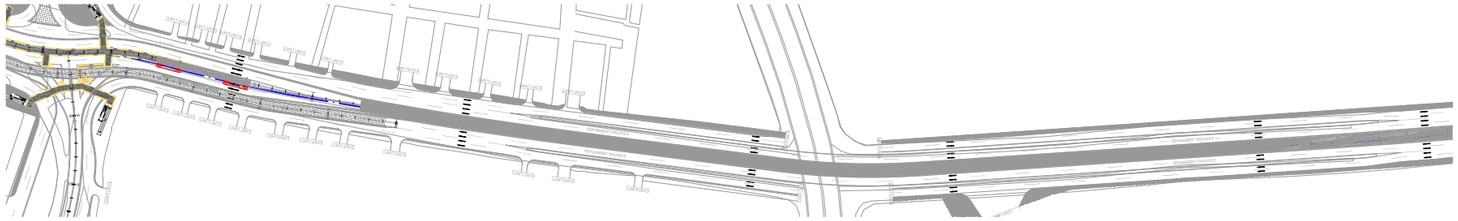


Fig. A-1

Sheet 2 of 3





N

NO	DEPTH (m)	EASTING	NORTHING
BH-1	10	317713.3900	2749930.9115
BH-2	20	316285.9555	2749676.2664
BH-3	10	314672.6281	2749330.1123
BH-4	20	314199.3254	2749234.6492
BH-5	10	313126.6370	2749014.5956
BH-6	20	312320.7449	2748852.1040
BH-7	20	311519.7886	2748688.6702
BH-8	10	310997.5032	2748583.7502
BH-9	10	310231.1346	2748429.1194
BH-10	10	309527.4475	2748285.5592
BH-11	10	308833.6509	2748146.5982
BH-12	20	308085.9062	2747994.3191
BH-13	40	307101.2876	2747760.1906
BH-14	30	306694.9926	2747677.5705
BH-15	30	307160.0766	2747819.2190
BH-16	40	306792.2257	2747757.3123
BH-17	10	305818.7149	2747619.4863
BH-18	25	304921.3548	2748157.8324
BH-19	10	304058.7409	2748668.9782
BH-20	10	303510.0586	2749158.7743
BH-21	10	303160.1063	2750213.1914
BH-22	10	303555.4038	2750813.7539
BH-23	25	303349.5211	2751533.2125

NO	DEPTH (m)	EASTING	NORTHING
TP-1	2.0	315845.9719	2749539.4965
TP-2	2.0	314490.0578	2749265.7051
TP-3	2.0	313398.4469	2749039.8281
TP-4	2.0	311809.9317	2748721.3173
TP-5	2.0	310634.1017	2748479.3777
TP-6	2.0	309336.5402	2748205.6524
TP-7	2.0	307917.6323	2747912.7095
TP-9	2.0	306305.7977	2747599.2977
TP-10	2.0	305059.6543	2748059.8175
TP-11	2.0	304341.6114	2748473.5889
TP-12	2.0	303252.4682	2749880.5053
TP-13	2.0	303727.5643	2750837.0644
TP-14	2.0	303585.4524	2751350.7985

LEGEND

- BORE HOLE (BH) (DEPTH 10m)
- BORE HOLE (BH) (DEPTH 20m)
- BORE HOLE (BH) (DEPTH 25m)
- BORE HOLE (BH) (DEPTH 30m)
- BORE HOLE (BH) (DEPTH 40m)
- TESTPIT (TP)

NOTES:

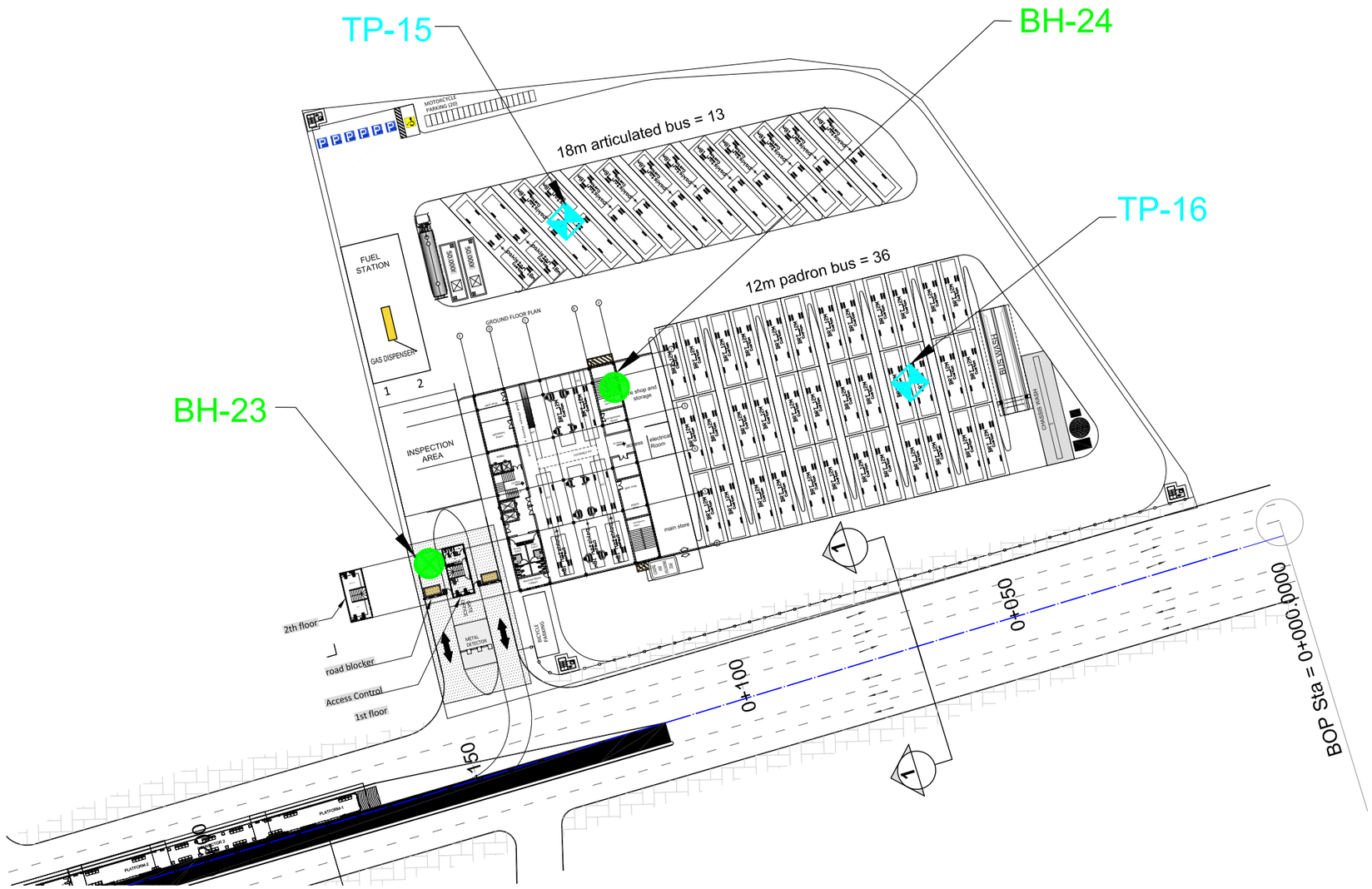
1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. THIS GEOTECHNICAL INVESTIGATION PLAN HAS BEEN DEVELOPED ON THE BASIS OF LAYOUT PLAN PROVIDED BY PROJECT MANAGER.
3. THE LOCATION OF BOREHOLES AND TESTPITS IS TENTATIVE AND MAY BE ADJUSTED AS PER SITE CONDITIONS OR AS DIRECTED BY THE ENGINEER.

0 100 m
SCALE

BUS RAPID TRANSIT SYSTEM (BRTS) - YELLOW LINE (FROM DAWOOD CHOWRANGI TO NUMAISH CHOWRANGI AND REGAL CHOWK VIA 8000 ROAD, KORANGI ROAD & FTC)

GEOTECHNICAL INVESTIGATION PLAN

Fig. A-1



NO	DEPTH (m)	NORTHING	EASTING
TP-15	2	2749545.46	319079.07
TP-16	2	2749481.20	319100.36

NO	DEPTH (m)	NORTHING	EASTING
BH-24	10	2749521.25	319018.13
BH-25	10	2749518.85	319063.58

LEGEND

- BORE HOLE (BH) (DEPTH 10m)
- TESTPIT (TP)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. THIS GEOTECHNICAL INVESTIGATION PLAN HAS BEEN DEVELOPED ON THE BASIS OF LAYOUT PLAN PROVIDED BY PROJECT MANAGER.
3. THE LOCATION OF BOREHOLES AND TESTPITS IS TENTATIVE AND MAY BE ADJUSTED AS PER SITE CONDITIONS OR AS DIRECTED BY THE ENGINEER.

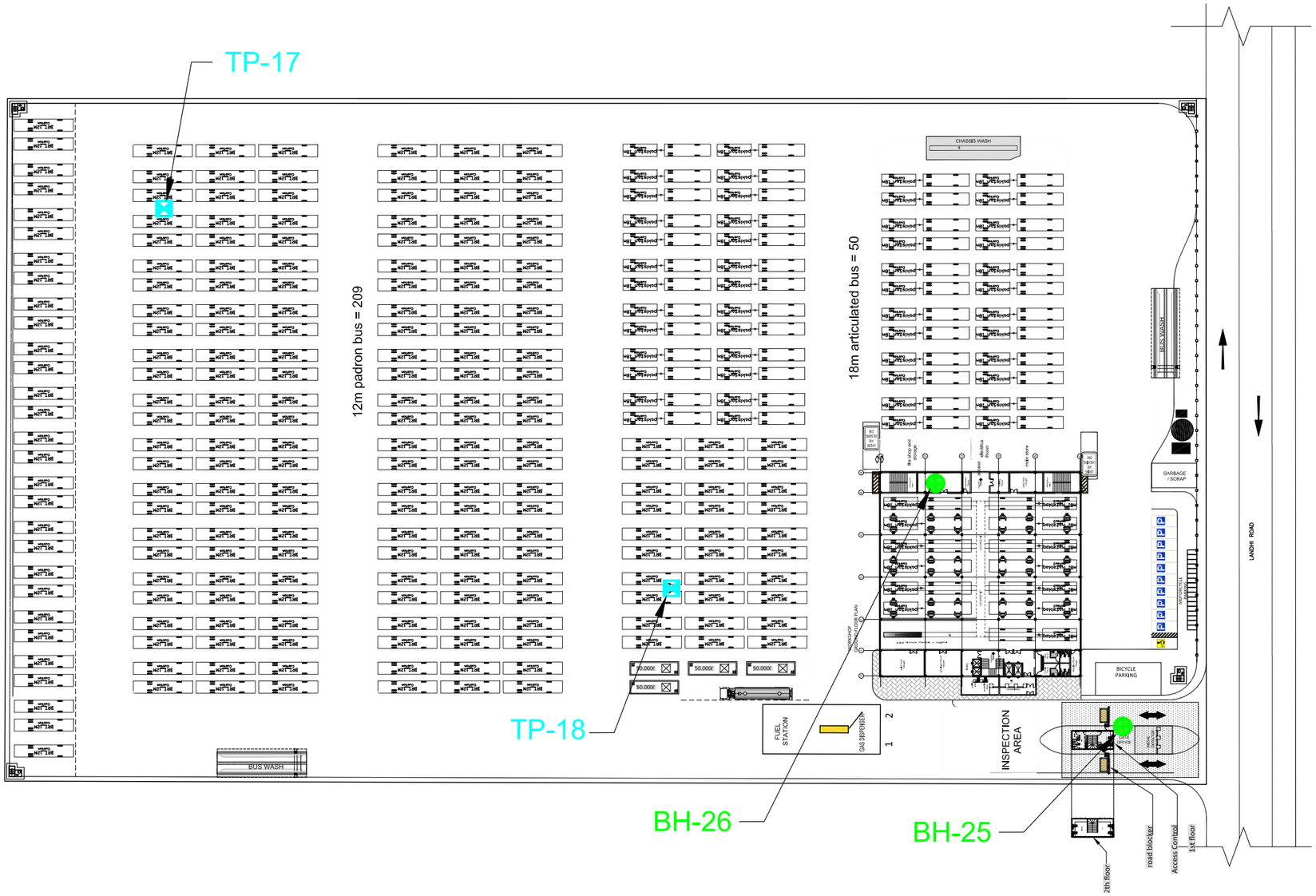
0 20 m

SCALE

BUS RAPID TRANSIT SYSTEM (BRTS) - YELLOW LINE (FROM DAWOOD CHOWRANGI TO NUMAISH CHOWRANGI AND REGAL CHOWK VIA 8000 ROAD, KORANGI ROAD & FTC)

GEOTECHNICAL INVESTIGATION PLAN
BUS DEPOT 1

Fig. A-1



NO	DEPTH (m)	NORTHING	EASTING
TP-17	2	2745907.55	309513.08
TP-18	2	2746029.40	309570.61

NO	DEPTH (m)	NORTHING	EASTING
BH-26	10	2746129.34	309580.20
BH-27	10	2746079.97	309537.50

LEGEND

- BORE HOLE (BH) (DEPTH 10m)
- TESTPIT (TP)

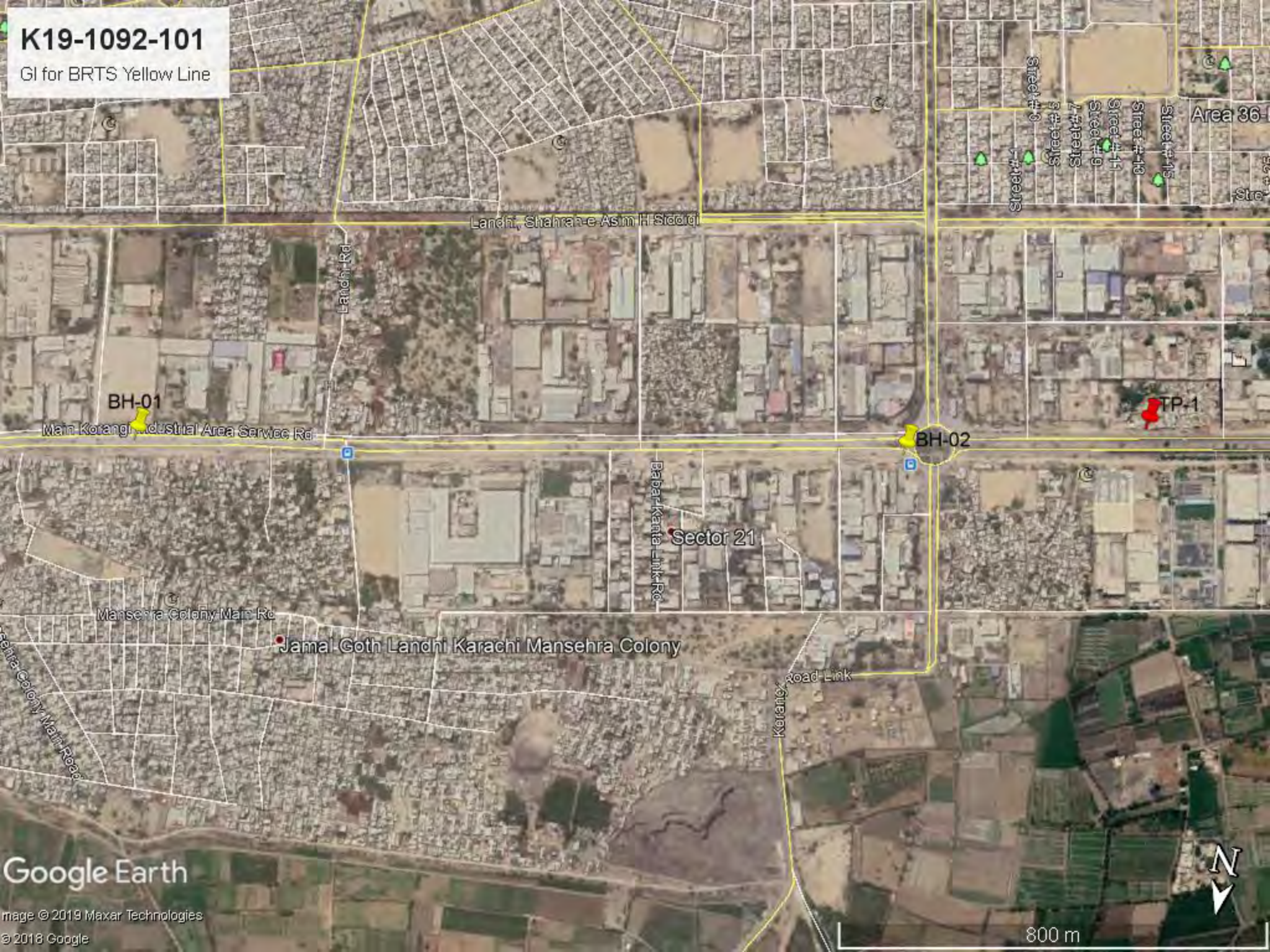
NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.
2. THIS GEOTECHNICAL INVESTIGATION PLAN HAS BEEN DEVELOPED ON THE BASIS OF LAYOUT PLAN PROVIDED BY PROJECT MANAGER.
3. THE LOCATION OF BOREHOLES AND TESTPITS IS TENTATIVE AND MAY BE ADJUSTED AS PER SITE CONDITIONS OR AS DIRECTED BY THE ENGINEER.

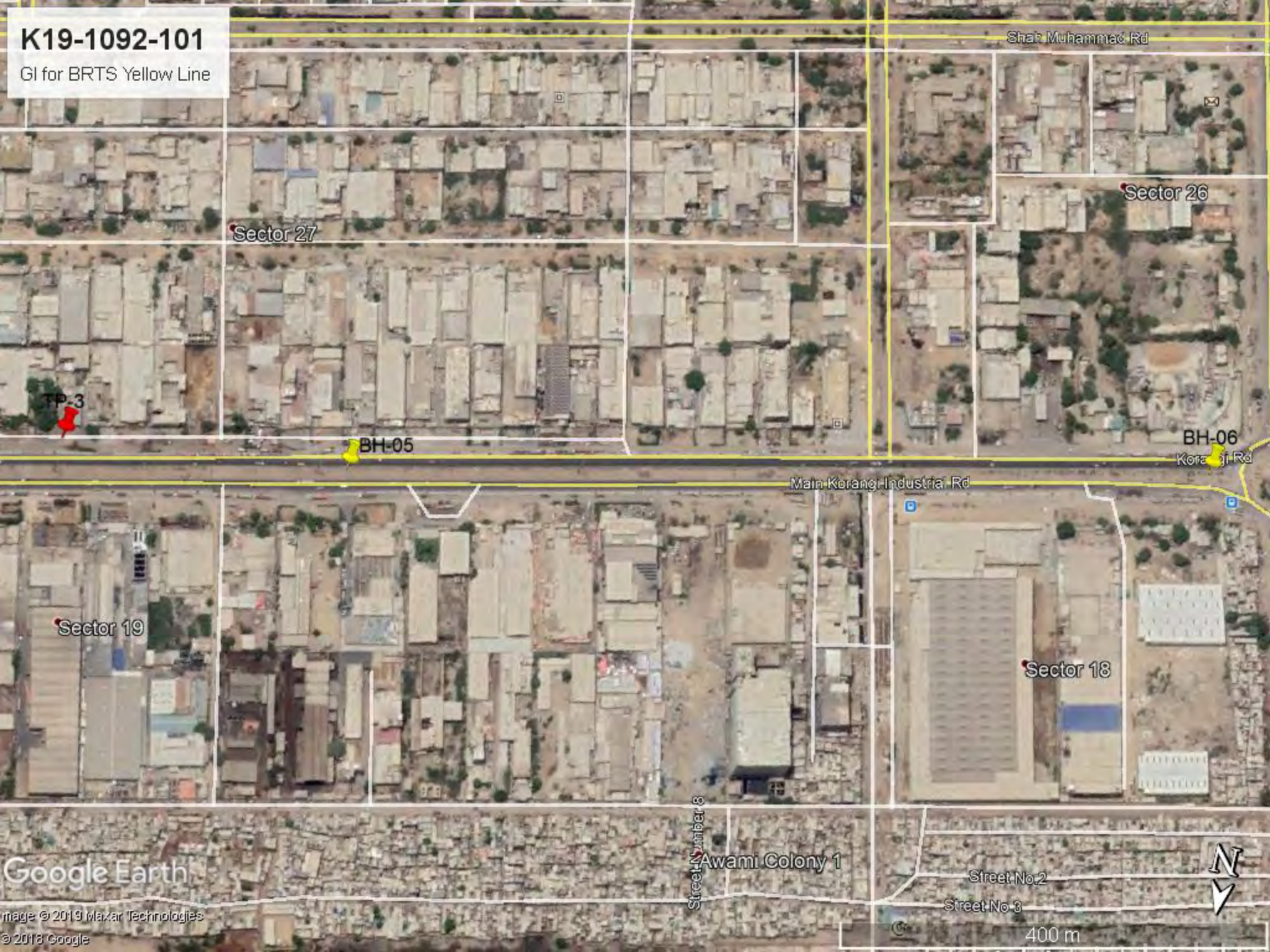
0 20 m
SCALE

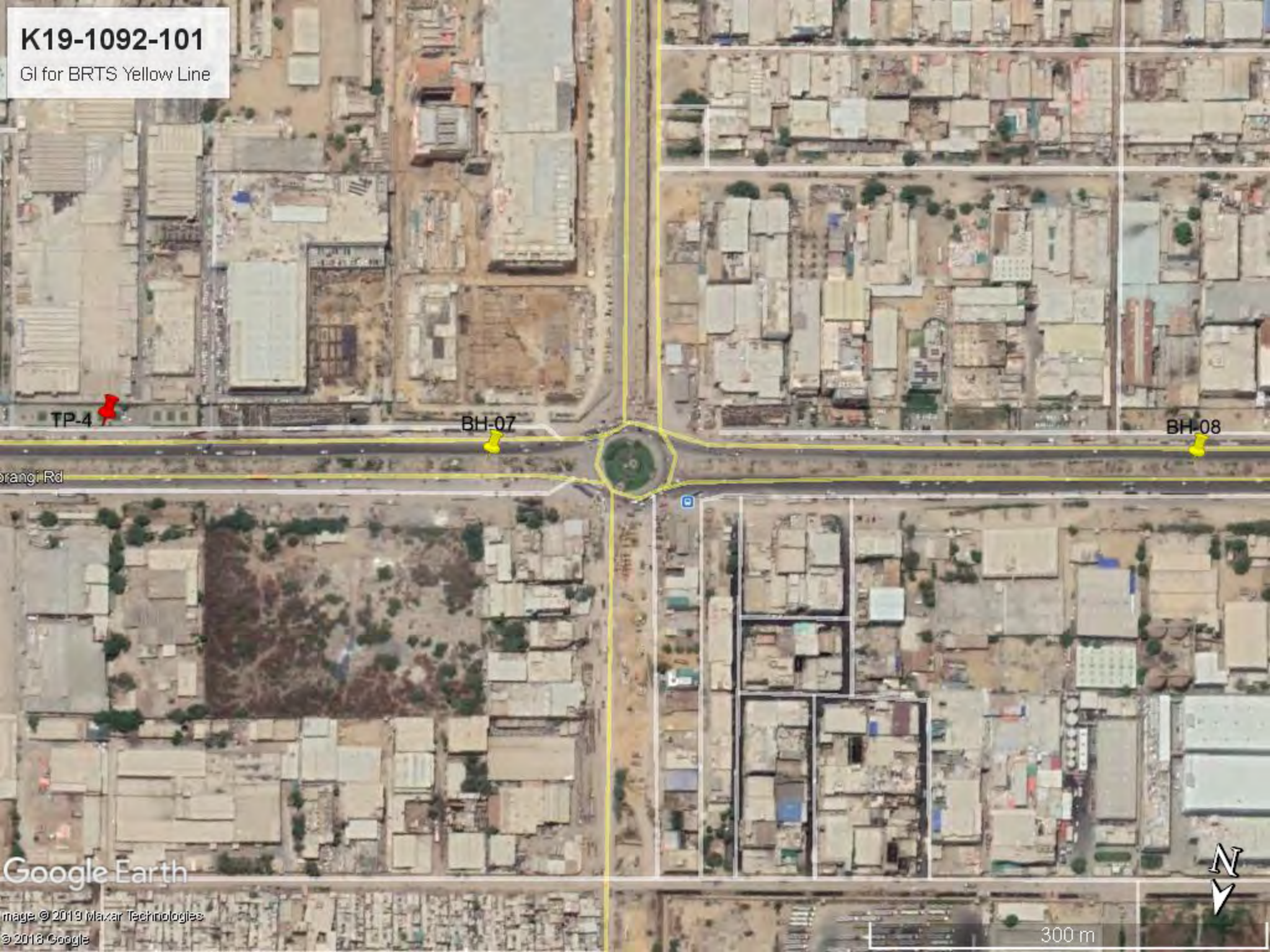
BUS RAPID TRANSIT SYSTEM (BRTS) - YELLOW LINE (FROM DAWOOD CHOWRANGI TO NUMAISH CHOWRANGI AND REGAL CHOWK VIA 8000 ROAD, KORANGI ROAD & FTC)

GEOTECHNICAL INVESTIGATION PLAN
BUS DEPOT 2


K19-1092-101
GI for BRTS Yellow Line
Landhi, Shahrah-e Asim H Siddiqi
Landhi Rd
BH-01
Main Korangi Industrial Area Service Rd
BH-02
TP-1
Area 36
Babar Kanta Link Rd
Sector 21
Mansehra Colony Main Rd
Jamal Goth Landhi Karachi Mansehra Colony
Korangi Road Link
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
800 m

K19-1092-101
GI for BRTS Yellow Line
TP-2
BH-03
BH-04
Korangi-Shah-Faisal Rd
Korangi-Shah-Faisal-Road
N
200 m
Google Earth
mage © 2019 Maxar Technologies
© 2018 Google


K19-1092-101
GI for BRTS Yellow Line
Shah Muhammad Rd
Sector 27
Sector 26
TP-3
BH-05
BH-06
Main Korangi Industria Rd
Sector 19
Sector 18
Awami Colony 1
Street Number 8
Street No.2
Street No.3
Google Earth
400 m
N
Image © 2019 Maxar Technologies
© 2018 Google


K19-1092-101
GI for BRTS Yellow Line
TP-4
BH-07
BH-08
rangi Rd
Google Earth
mage © 2019 Maxar Technologies
© 2018 Google
300 m
N

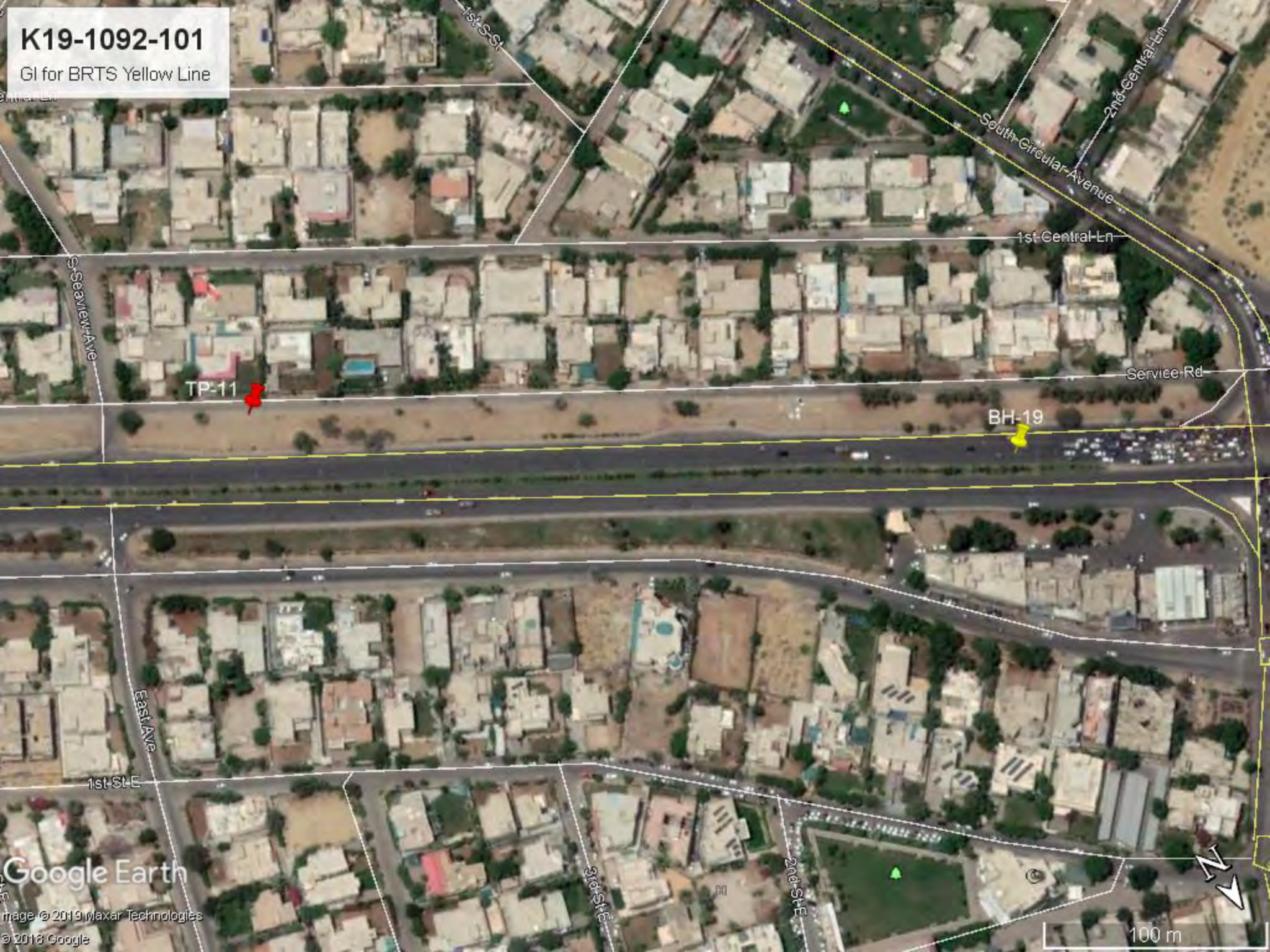
K19-1092-101
GI for BRTS Yellow Line
Shah Muh
ector 24
TP-5
BH-09
Main Korangi Industrial Local Road
BH-10
TP-6
Main Korangi Industrial Lo
Korangi Rd
Sector 16
Sector 15
Google Earth
mage © 2019 Maxar Technologies
© 2018 Google
N
500 m

K19-1092-101
GI for BRTS Yellow Line
Shah Muhammad Rd
Sector 23
BH-11
Korangi Rd
BH-12
TP-7
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
400 m
N

K19-1092-101
GI for BRTS Yellow Line
TP-8
BH-13
BH-15
Korangi Rd
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
100 m

K19-1092-101
GI for BRTS Yellow Line
BH-14
Korangi Rd
BH-16
Construction Works Only
N
100 m
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google

K19-1092-101
GI for BRTS Yellow Line
TP-9
BH-17
Korangi Rd
Qayyumabad Rd
Korangi Industrial Estate Rd
KPT Interchange
Expressway
Shaheed-e-Millat Expy
Phase II Ext. Rd
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
200 m


K19-1092-101
GI for BRTS Yellow Line
South Circular Avenue
2nd Central Ln
1st Central Ln
S Seaview Ave
Service Rd
TP-11
BH-19
East Ave
1st St E
3rd St E
2nd St E
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
100 m

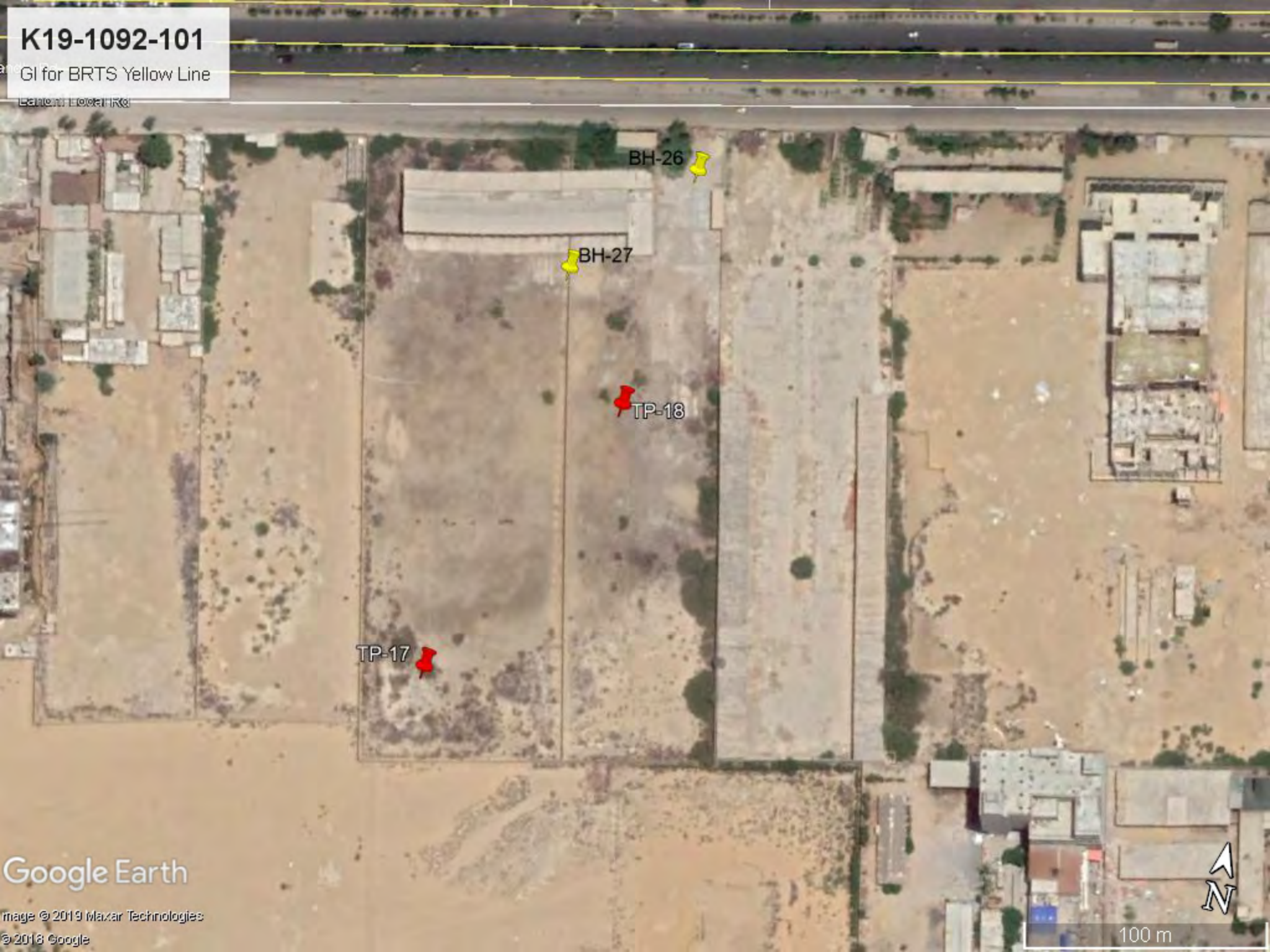
K19-1092-101
GI for BRTS Yellow Line
BH-20
Korangi Rd
Korangi Rd
N Central Ave
West Ave
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
100 m

K19-1092-101
GI for BRTS Yellow Line
TP-12
BH-21
Korangi Rd
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
100 m

K19-1092-101
GI for BRTS Yellow Line
TP-13
Shahrah-e-Faisal Service Rd N
Shahrah-e-Faisal
BH-22
Shahrah-e-Faisal Service Rd S
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
100 m

K19-1092-101
GI for BRTS Yellow Line
Captain Fareed Bukhari Shaheed Rd
Masjid-e-Tayyaba St
11th Back Alley
TP-14
BH-23
Shahrah-e-Qaideen
Shahrah-e-Quaideen
Tariq Rd
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
100 m

K19-1092-101
GI for BRTS Yellow Line
Landhi Rd
Landhi Flyover
BH-24
BH-25
Main Landhi Industrial Area Rd
N
100 m
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google


K19-1092-101
GI for BRTS Yellow Line
BH-26
BH-27
TP-18
TP-17
Google Earth
Image © 2019 Maxar Technologies
© 2018 Google
N
100 m

Appendix B

Borehole & Test Pit Logs

Log BH-01

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL: - Not Encountered
Drill Date: 17.07.2019
Logged By: AM
Elevation: 19.50(m) from MSL
Easting: 317713.3900
Northing: 2749930.9115
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Yellowish brown, gravelly sand*			0																						0	
1		U	**SANDY SILT** *Yellowish brown, medium stiff, fne grained sandy, SILT*	* 6		1																						1	SPT - 1
2		U	**SILTY SAND** *Yellowish brown, medium dense, fine grained SAND, silty*	* 12		2																						2	SPT - 2
3		U	**SILTY SAND** *Yellowish brown, loose, fine to medium grained, little clay, some silt*	* 8		3	SM	1.2	60.2	25.5	13.1	NLL	-	NPI														3	SPT - 3
4		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, medium dense to very dense, fine to coarse grained SAND, traces of gravel at places*	* 28		4																						4	SPT - 4
5		U		* 37		5																						5	SPT - 5
6		U		* 44		6																						6	SPT - 6
7		U		* 50		7																						7	SPT - 7
8		U		* 35		8																						8	SPT - 8
9		U	**SILTY SAND** *Yellowish brown, dense to very dense, fine to medium grained, silty, traces of clay and gravel*	* 36		9	SM	1.8	57.4	32.4	8.4	NLL	-	NPI														9	SPT - 9
10		U		* 50		10																						10	SPT - 10

End of Log @ 10 (m)

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-02

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 7.93 (m)
Drill Date: 18.07.2019
Logged By: MA
Elevation: 22.25(m) from MSL
Easting: 316285.9555
Northing: 2749676.2664
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with asphlat*			0																						0	
1		U	**SANDY CLAY** *Yellowish brown, soft, fine grained sandy silty CLAY*	* 3		1																						1	SPT - 1
2		U	**SILTY SAND** *Yellowish brown, medium dense, fine to medium grained, silty SAND*	* 13		2																						2	SPT - 2
3		U	**SAND WITH TRACES OF SILT & GRAVEL** *Yellowish brown, medium dense, fine to coarse grained, traces of silt and gravel*	* 24		3	SW	6.4	93.5	0.1		NLL	-	NPI														3	SPT - 3
4		+				4																						4	UDS - 1
5		U	**SILTY SAND** *Yellowish brown, medium dense, fine to medium grained silty SAND*	* 24		5																						5	SPT - 4
6		+	**FINE TO MEDIUM GRAINED SAND** *Yellowish brown, fine to medium grained SAND*			6																						6	UDS - 2
7		U	**SAND WITH LITTLE GRAVEL** *Yellowish brown, dense to very dense, fine to coarse grained, little gravel, traces of silt*	* 50		7																						7	SPT - 5
8	▽	U		* 49		8	SW	16.5	81	2.5		NLL	-	NPI	4	1.88	1.96											8	SPT - 6
9		U		* 50		9																						9	SPT - 7
10		U		* 35		10																						10	SPT - 8

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-02

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 7.93 (m)
Drill Date: 18.07.2019
Logged By: MA
Elevation: 22.25(m) from MSL
Easting: 316285.9555
Northing: 2749676.2664
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**FINE TO COARSE GRAINED SAND** *Yellowish brown, dense, fine to coarse grained SAND*	* 35		10																						10	SPT - 8
11		U	**SANDY CLAY** *Yellowish brown, hard, fine grained sandy, little silt, traces of gravel*	* 30		11	SC	5.4	58.2	16	20.4	29.7	21.4	8.3														11	SPT - 9
12		U		* 50		12																						12	SPT - 10
13		U		* 50		13																						13	SPT - 11 SPT Drive - 125mm
14		U	**SAND WITH TRACES OF SILT & GRAVEL** *Yellowish brown, very dense, fine to coarse grained, traces of silt and gravel*	* 50		14																						14	SPT - 12 SPT Drive - 150mm
15		U		* 50		15	SP	5.5	93	1.5		NLL	-	NPI														15	SPT - 13 SPT Drive - 150mm
16		U		* 50		16																						16	SPT - 14 SPT Drive - 75mm
17		U	**SANDY SILT** *Yellowish brown, hard, fine grained sandy, SILT*	* 50		17																						17	SPT - 15 SPT Drive - 25mm
18		U		* 50		18																						18	SPT - 16 SPT Drive - 50mm
19		U	**SANDY SILT** *Yellowish brown, hard, fine grained sandy, some clay, traces of gravel*	* 50		19	ML	1	41.4	28.7	28.9	29.3	26	3.3														19	SPT - 17
20		U		* 50		20																						20	SPT Drive - 125mm

End of Log @ 20 (m)

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-03

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 23.08.2019
Logged By: MA
Elevation: 14.63(m) from MSL
Easting: 314672.6281
Northing: 2749330.1123
Rev. BY: FA

Company Info.
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with asphalt*			0																						0	
1		U	**SANDY SAND** *Yellowish brown, loose, fine grained sandy SILT*	* 8		1																						1	SPT - 1
2		U	**SAND WITH LITTLE SILT** *Yellowish brown, loose, fine to medium grained, little silt, traces of clay and gravel*	* 10		2	SM	1.7	73.6	17.5	7.2	NLL	-	NPI											0.01	0.22	2	SPT - 2
3		U	**FINE TO COARSE GRAINED SAND** *Yellowish brown, medium dense to dense, fine to coarse grained SAND*	* 25		3																						3	SPT - 3
4		U		* 48		4																						4	SPT - 4
5		U	**SAND WITH SOME SILT** *Yellowish brown, medium dense to dense, fine to medium grained SAND with some silt*	* 30		5																						5	SPT - 5
6		U		* 45		6																						6	SPT - 6
7		+	**SILT WITH SOME SAND** *Yellowish brown, very stiff, some fine grained sand, little clay, traces of gravel*			7	ML	0.5	20.6	61.6	17.3	NLL	-	NPI	6.4	1.89	2.01											7	UDS - 1
8		U		* 27		8																						8	SPT - 7
9		U	**SILTY CLAY** *Yellowish brown, hard, silty CLAY with some fine grained sand*	* 50		9																						9	SPT - 8
10		U		* 50		10																						10	SPT - 9

End of Log @ 10 (m)

Sample Types
- Disturbed
- + Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-04

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 11.5 (m)
Drill Date: 26.07.2019
Logged By: MA
Elevation: 15.84(m) from MSL
Easting: 314199.3254
Northing: 2749234.6492
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0–1		U	**SILTY SAND** *Yellowish brown, loose, fine to medium grained, silty SAND*	* 10		0–1																						1	SPT - 1
1–2		U	**SILTY SAND** *Yellowish brown, medium dense, fine to coarse grained, silty SAND with traces of gravel*	* 17		1–2																						2	SPT - 2
2–3		U	**SAND WITH SOME GRAVEL** *Yellowish brown, dense to very dense, fine to coarse grained, some gravel, traces of silt*	* 50		2–3																						3	SPT - 3
3–4		U		* 50		3–4	SW-SM	25.9	65.3	8.8		NLL	-	NPI														4	SPT - 4
4–5		U		* 37		4–5																						5	SPT - 5
5–6		U	**CLAYEY SAND** *Yellowish brown, very dense, fine to medium grained, clayey SAND*	* 50		5–6																						6	SPT - 6
6–7		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to medium grained SAND with traces of gravel*	* 50		6–7																						7	SPT - 7
7–8		U		* 50		7–8																						8	SPT - 8
8–9		U	**SAND WITH SOME GRAVEL** *Yellowish brown, very dense, fine to coarse grained, some gravel, traces of silt*	* 50		8–9																						9	SPT - 9
9–10		+				9–10	SP-SM	27.3	63.2	9.5		NLL	-	NPI	5.6	1.92	2.03											10	UDS - 1

Sample Types
- Disturbed
- + Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-04

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 11.5 (m)
Drill Date: 26.07.2019
Logged By: MA
Elevation: 15.84(m) from MSL
Easting: 314199.3254
Northing: 2749234.6492
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		+	**SAND WITH SOME GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND with some gravel*	* 50		10	SP-SM	27.3	63.2	9.5		NLL	-	NPI	5.6	1.92	2.03											10	UDS - 1
11	▽	U		* 50		11																						11	SPT - 10 SPT Drive - 125mm
12		U		* 50		12																						12	SPT - 11 SPT Drive - 350mm
13		U		* 50		13																						13	SPT - 12 SPT Drive - 125mm
14		U	**PIECES OF SANDSTONE** *Yellowish brown, thin layer of immature sandstone with gravel*	* 50		14																						14	SPT - 13 SPT Drive - 100mm
15		U	**CLAY / SILT** *Yellowish brown, hard, clayey silt/silty clay, fine grained sandy*	* 50		15																						15	SPT - 14 SPT Drive - 125mm
16		U		* 50		16																						16	SPT - 15 SPT Drive - 125mm
17		U		* 50		17	CL-ML		34	32.7	33.3	21.3	17.1	4.2														17	SPT - 16 SPT Drive - 300mm
18		U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained silty SAND with traces of clay*	* 50		18																						18	SPT - 17 SPT Drive - 200mm
19		U		* 50		19																						19	SPT - 18 SPT Drive - 375mm
20		U		* 50		20																						20	SPT - 19

End of Log @ 20 (m)

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-05

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL: - Not Encountered
Drill Date: 06.08.2019
Logged By: SH
Elevation: 13.10(m) from MSL
Easting: 313126.6370
Northing: 2749014.5956
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0		●	**SILTY SAND** *Yellowish brown, medium dense, fine grained, silty, traces of clay*			0																						0	DS - 1
1						1																						1	
2		U		* 21		2																						2	SPT - 1
3		U		* 26		3	SM		54.9	35.7	9.4	NLL	-	NPI														3	SPT - 2
4		U	**SAND WITH TRACES OF SILT & GRAVEL** *Yellowish brown, very dense, fine to coarse grained sand, traces of silt and gravel*	* 50		4																						4	SPT - 3
5		U		* 50		5																						5	SPT - 4
6		U		* 50		6																						6	SPT - 5 SPT Drive - 75mm
7		U	**SAND WITH LITTLE SILT** *Yellowish brown, very dense, fine to medium grained, little silt, traces of gravel*	* 50		7																						7	SPT - 6 SPT Drive - 75mm
8		U		* 50		8																						8	SPT - 7 SPT Drive - 100mm
9		U		* 50		9	SW-SM	2.2	86.3	11.5		NLL	-	NPI														9	SPT - 8 SPT Drive - 50mm
10		U		* 50		10																						10	SPT - 9

End of Log @ 10 (m)

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations:
LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI
C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU)
Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.
w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow
CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-06

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 10.45 (m)
Drill Date: 06.08.2019
Logged By: SH
Elevation: 10.06(m) from MSL
Easting: 312320.7449
Northing: 2748852.1040
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0		● ●	**FILLING MATERIAL** *Filled with gravelly*			0																						0	DS - 1 DS - 2
1			**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND with traces of gravel*			1																						1	
2		U		* 50		2																						2	SPT - 1
3		U	**SANDY, CLAYEY SILT** *Greyish brown, hard, fine grained sandy, clayey*	* 50		3	ML		30.4	36.2	33.4	21.4	18.2	3.2														3	SPT - 2
4		U	**CLAYEY, SILTY SAND** *Greyish brown, very dense, clayey silty sand/ clayey sandy silt*	* 50		4																						4	SPT - 3
5		U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained, silty SAND, traces of gravel*	* 50		5																						5	SPT - 4 SPT Drive - 375mm
6		U		* 50		6																						6	SPT - 5
7		U	**SANDY GRAVEL** *Yellowish brown, very dense, sandy GRAVEL*	* 50		7																						7	SPT - 6 SPT Drive - 300mm
8		U	**SILTY CLAY** *Greyish brown, very stiff to hard, silty, traces of sand*	* 29		8	CL		2	43.8	54.2	31.7	22.1	9.6														8	SPT - 7
9		U		* 46		9																						9	SPT - 8
10		U	**(continued ...)**	* 50		10																							SPT - 9

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations:
LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI
C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU)
Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.
w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow
CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-06

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 10.45 (m)
Drill Date: 06.08.2019
Logged By: SH
Elevation: 10.06(m) from MSL
Easting: 312320.7449
Northing: 2748852.1040
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10	▽	U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained SAND, silty, traces of gravel*	* 50		10																						10	SPT - 9 SPT Drive - 300mm
11		U		* 50		11																						11	SPT - 10 SPT Drive - 100mm
12		U	**CLAY / SILT** *Greenish grey, very stiff to hard, clayey silt/ silty clay, fine grained sandy*	* 24		12	CL-ML		37	31.3	31.7	26.3	20.9	5.4														12	SPT - 11
13		U		* 33		13																						13	SPT - 12
14		U	**SAND WITH LITTLE SILT** *Yellowish brown, very dense, fine to medium grained, little silt, traces of gravel*	* 50		14																						14	SPT - 13 SPT Drive - 300mm
15		U		* 50		15	SM	2.5	85.5	12		NLL	-	NPI														15	SPT - 14 SPT Drive - 100mm
16		U		* 50		16																						16	SPT - 15 SPT Drive - 100mm
17		U	**SANDY GRAVEL** *Yellowish brown, very dense, sandy GRAVELS*	* 50		17																						17	SPT - 16 SPT Drive - 75mm
18		+	**CLAYEY SILT** *Brown, hard, clayey, some fine grained sand*			18	ML		27.6	37.6	34.8	35.2	26.7	8.5	24.8	1.52	1.9							0.45				18	UDS - 1
19		U	**SANDY CLAY** *Greyish brown, very dense, clayey silty sand/ silty sandy clay*	* 50		19																						19	SPT - 17 SPT Drive - 300mm
20		U		* 50		20																						20	SPT - 18

End of Log @ 20 (m)

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
▽ Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
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Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-07

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 9.76 (m)
Drill Date: 25.08.2019
Logged By: MA
Elevation: 8.23(m) from MSL
Easting: 311519.7886
Northing: 2748688.6702
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Yellowish brown, fine to coarse sand with gravel*			0																						0	
1		U	**SILTY SAND** *Yellowish brown, loose to medium dense, fine to medium grained SAND, silty*	* 9		1																						1	SPT - 1
2		U		* 16		2																						2	SPT - 2
3		U	**SAND WITH SOME CLAY & SILT** *Yellowish brown, medium dense, fine to medium grained SAND with some clayey silt*	* 17		3																						3	SPT - 3
4		U	**CLAYEY SILT** *Yellowish brown, very stiff, clayey, some fine grained sand, traces of gravel*	* 26		4	ML	3.4	23.6	41.6	31.4	18.1	16	2.1														4	SPT - 4
5		U	**SILTY SAND** *Yellowish brown, dense, fine to medium grained silty SAND*	* 33		5																						5	SPT - 5
6		U	**GRAVELLY SAND** *Yellowish brown, dense, fine to coarse grained SAND, gravelly*	* 34		6																						6	SPT - 6
7		U	**CLAYEY SILT** *Yellowish brown, very stiff to hard, clayey, traces of sand*	* 18		7																						7	SPT - 7
8		U		* 33		8	ML		8.4	47.1	44.5	41.5	31.6	9.9														8	SPT - 8
9		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND, traces of gravel*	* 50		9																						9	SPT - 9 SPT Drive - 150mm
10	▽	U		* 50		10																						10	SPT - 10

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-07

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 20 (m)
GWL: 9.76 (m)
Drill Date: 25.08.2019
Logged By: MA

Elevation: 8.23(m) from MSL
Easting: 311519.7886
Northing: 2748688.6702
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**GRAVELLY SAND** *Yellowish brown, very dense, fine to coarse grained SAND, gravelly*	* 50		10																						10	SPT - 10
11		U		* 50		11																						11	SPT - 11 SPT Drive - 75mm
12		U	**FINE TO MEDIUM GRAINED SAND** *Yellowish brown, very dense, fine to medium grained SAND*	* 50		12																						12	SPT - 12
13		+	**GRAVEL WITH SOME SILT** *Yellowish brown, very dense, some fine grained sand, some silt, little clay*			13	GM	34.1	27	28.4	10.5	NLL	-	NPI	9.3	1.98	2.16												13	UDS - 1
14		U	**FINE TO COARSE GRAINED SAND** *Yellowish brown, very dense, fine to coarse grained SAND*	* 50		14																						14	SPT - 13 SPT Drive - 100mm
15		U		* 50		15																						15	SPT - 14 SPT Drive - 150mm
16		U		* 50		16																						16	SPT - 15 SPT Drive - 100mm
17		U	**CLAYEY SILT** *Yellowish brown, hard, silty clay/ clayey silt, traces of sand*	* 50		17																						17	SPT - 16
18		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, traces of sand and gravel*	* 50		18	ML	3.6	9.8	47	39.6	37.1	30.1	7														18	SPT - 17
19		U		* 50		19																						19	SPT - 18
20		U		* 50		20																						20	SPT - 19

End of Log @ 20 (m)

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-08

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 06.08.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 310997.5032
Northing: 2748583.7502
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled material*			0																						0	
1		U	**SILTY SAND** *Yellowish brown, dense, fine to medium grained, silty SAND*	* 30		1																						1	SPT - 1
2		U	**SANDY SILT** *Brown, hard, fine grained sandy, little clay*	* 35		2	ML		40.1	40.7	19.2	NLL	-	NPI														2	SPT - 2
3		U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained, silty SAND with traces of gravel at places*	* 50		3																						3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U		* 50		5																						5	SPT - 5
6		U	**CLAYEY SILT** *Greyish brown, very stiff, clayey, little fine grained sand*	* 24		6																						6	SPT - 6
7		+				7	ML		15.4	43.7	40.9	36.3	32.2	4.1	27.5	1.5	1.91							1.33		0.02	0.28	7	UDS - 1
8		U		* 29		8																						8	SPT - 7
9		U	**SAND WITH LITTLE CLAY** *Greyish brown, medium dense to very dense, fine to coarse grained, little clay, traces of gravel and clay*	* 20		9																						9	SPT - 8
10		U		* 50		10	SM	8.4	69.4	16.2	6	NLL	-	NPI														10	SPT - 9

End of Log @ 10 (m)

Sample Types
- Disturbed
- + Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-09

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 20 (m)
GWL: 8.65 (m)
Drill Date: 03.08.2019
Logged By: SH
Elevation: 7.92(m) from MSL
Easting: 310231.1346
Northing: 2748429.1194
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0–1		U	**SILTY SAND** *Yellowish brown, medium dense to dense, fine to medium grained, silty*	* 35		0–1																						1	SPT - 1
1–2		U		* 14		1–2																						2	SPT - 2
2–3		U	**SANDY SILT** *Yellowish brown, very stiff to hard, fine grained sandy, some clay, traces of gravel*	* 20		2–3																						3	SPT - 3
3–4		U		* 44		3–4	ML	0.5	30.4	48.5	20.6	NLL	-	NPI														4	SPT - 4
4–5		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND, traces of gravel*	* 50		4–5																						5	SPT - 5
5–6		U		* 50		5–6																						6	SPT - 6
6–7		U	**CLAYEY SILT** *Grey, stiff to very stiff, clayey, traces of sand*	* 14		6–7																						7	SPT - 7
7–8		U		* 22		7–8	ML		2	52.9	45.1	31.5	27.3	4.2														8	SPT - 8
8–9	▽	+	**GRAVELLY SAND** *Greyish brown, very dense, fine to coarse grained SAND, gravelly*			8–9																							UDS - 1
9–10		U		* 50		9–10																						9	SPT - 9 SPT Drive - 100mm
		U		* 50																								10	SPT - 10

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-09

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 20 (m)
GWL: 8.65 (m)
Drill Date: 03.08.2019
Logged By: SH

Elevation: 7.92(m) from MSL
Easting: 310231.1346
Northing: 2748429.1194
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**GRAVELLY SAND** *Greyish brown, very dense, fine to coarse grained SAND, gravelly*	* 50		10																						10	SPT - 10 SPT Drive - 110mm
11		U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained SAND, silty*	* 50		11																						11	SPT - 11 SPT Drive - 75mm
12		U		* 50		12																						12	SPT - 12
13		U	**SAND WITH LITTLE SILT** *Greyish brown, very dense, fine to medium grained, little silt, traces of gravel and clay*	* 50		13																						13	SPT - 13
14		U		* 50		14	SM	4.9	78.1	11.5	5.5	NLL	-	NPI														14	SPT - 14 SPT Drive - 225mm
15		U		* 50		15																						15	SPT - 15 SPT Drive - 225mm
16		U		* 50		16																						16	SPT - 16 SPT Drive - 300mm
17		U	**CLAYEY SILT** *Greyish brown, hard, clayey, traces of sand*	* 50		17																						17	SPT - 17
18		+				18	ML		2.4	52.7	44.9	31.7	28.9	2.8	23.8	1.55	1.92							1.17				18	UDS - 2
19		U		* 48		19																						19	SPT - 18
20		U	End of Log @ 20 (m)	* 50		20																						20	SPT - 19

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-10

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL: - Not Encountered
Drill Date: 02.08.2019
Logged By: SH & QM
Elevation: 7.92(m) from MSL
Easting: 3095227.4475
Northing: 2748285.5592
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with sand and gravel*			0																						0	
1		U		* 50		1																						1	SPT - 1
2		U	**SILT WITH SOME CLAY** *Yellowish brown, hard, some clay, little fine grained sand*	* 50		2																						2	SPT - 2
3		U		* 40		3																						3	SPT - 3
4		U		* 50		4	ML		14.8	63.8	21.4	NLL	-	NPI														4	SPT - 4
5		U		* 44		5																						5	SPT - 5
6		U	**SILTY SAND** *Yellowish brown, dense to very dense, fine to coarse grained, silty, traces of gravel*	* 50		6																						6	SPT - 6 SPT Drive - 225mm
7		U		* 50		7																						7	SPT - 7 SPT Drive - 75mm
8		U		* 50		8																						8	SPT - 8
9		U	**CLAY / SILT** *Yellowish brown, hard, clayey silt/ silty clay, traces of sand and gravel*	* 34		9	CL-ML	0.8	5.4	45.9	47.9	28.9	22.1	6.8														9	SPT - 9 SPT Drive - 75mm
10		U		* 50		10																						10	SPT - 10

End of Log @ 10 (m)

Sample Types: Disturbed; Undisturbed; Shelby / U4; Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations:
LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI
C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU)
Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.
w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow
CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-11

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 04.08.2019
Logged By: SH
Elevation: 7.62(m) from MSL
Easting: 308833.6509
Northing: 2748146.5982
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with yellowish brown, very loose to loose, fine to medium grained, little silt and gravel, traces of clay*			0																						0	
1		U		* 3		1																						1	SPT - 1
2		U		* 10		2	SM	17.3	56.2	18.1	8.4	NLL	-	NPI														2	SPT - 2
3		U	**SAND WITH GRAVELS** *Yellowish brown, very dense, fine to coarse grained SAND with gravel*	* 50		3																						3	SPT - 3 SPT Drive - 50mm
4		U	**SILTY SAND** *Yellowish brown, medium dense, fine to medium grained SAND, silty*	* 14		4																						4	SPT - 4
5		U	**CLAYEY SILT** *Yellowish brown, stiff to very stiff, clayey silt/ silty clay, some sand*	* 19		5																						5	SPT - 5
6		U		* 9		6																						6	SPT - 6
7		U	**FINE TO MEDIUM GRAINED SAND** *Yellowish brown, dense, fine to medium grained, SAND*	* 49		7																						7	SPT - 7
8		U	**SAND WITH TRACES OF SILT & GRAVEL** *Yellowish brown, very dense, fine to coarse grained, traces of silt and gravel*	* 50		8	SW-SM	1.5	89.5	9		NLL	-	NPI														8	SPT - 8 SPT Drive - 200mm
9		U		* 50		9																						9	SPT - 9 SPT Drive - 225mm
10		U		* 50		10																						10	SPT - 10

End of Log @ 10 (m)

Sample Types: Disturbed; Undisturbed; Shelby / U4; Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-12

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 20 (m)
GWL: 10.97 (m)
Drill Date: 02.08.2019
Logged By: SH

Elevation: 7.92(m) from MSL
Easting: 308085.9062
Northing: 2747994.3191
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Yellowish brown, gravelly sand*			0																						0	
1		SPT		* 50		1																						1	SPT - 1
2		SPT	**SAND WITH LITTLE SILT & CLAY** *Yellowish brown, medium dense to very dense, fine to medium grained, little silt and clay*	* 18		2																						2	SPT - 2
3		SPT		* 21		3																						3	SPT - 3
4		SPT		* 26		4	SM		70.9	18.6	10.5	NLL	-	NPI														4	SPT - 4
5		SPT		* 40		5																						5	SPT - 5
6		SPT		* 50		6																						6	SPT - 6
7		SPT	**FINE GRAINED SAND** *Blackish grey, very loose, fine grained SAND*	* 1		7																						7	SPT - 7
8		SPT	**CLAYEY SILT** *Blackish grey, very soft to very stiff, clayey SILT*	* 21		8																						8	SPT - 8
9		SPT	**FINE TO COARSE GRAINED SAND** *Blackish grey, dense, fine to coarse grained SAND*	* 31		9																						9	SPT - 9
10		SPT	**(continued ...)**	* 27		10																						10	SPT - 10

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-12

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 20 (m)
GWL: 10.97 (m)
Drill Date: 02.08.2019
Logged By: SH

Elevation: 7.92(m) from MSL
Easting: 308085.9062
Northing: 2747994.3191
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**CLAYEY SILT** *Yellowish brown, very stiff, clayey, traces of sand*	* 27		10	ML		1.6	50.5	47.9	19.3	15.8	3.5	19.8	1.59	1.9				0.58	0.03	11.3	1.28		0.01	0.19	10	SPT - 10
11	⧖	□				11																					11	UDS - 1
12		U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained SAND, silty*	* 50		12																					12	SPT - 11 SPT Drive - 150mm
13		U		* 50		13																					13	SPT - 12 SPT Drive - 150mm
14		U		* 50		14																					14	SPT - 13 SPT Drive - 125mm
15		U	**SANDY SILT** *Yellowish brown, hard, fine grained sandy, some clay, traces of gravel*	* 50		15																					15	SPT - 14 SPT Drive - 75mm
16		U		* 50		16	ML	9	33.4	31.7	25.9	14.5	13.1	1.4														16	SPT - 15
17		U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained SAND, silty*	* 50		17																					17	SPT - 16 SPT Drive - 25mm
18		U		* 50		18																					18	SPT - 17 SPT Drive - 400mm
19		U	**SILTY CLAY** *Yellowish brown, hard, silty CLAY, thin layer of fine sand at end*	* 50		19																					19	SPT - 18
20		U		* 50		20																					20	SPT - 19

End of Log @ 20 (m)

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ⧖ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-13

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 29 (m)
GWL: 0.76 (m)
Drill Date: 19.09.2019
Logged By: MA
Elevation: 8.23(m) from MSL
Easting: 307101.2876
Northing: 2747780.1905
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Slush*			0																						0	
1	▽	SPT	**SILTY SAND** *Yellowish brown, very loose to medium dense, fine grained, silty sand with traces of clay*	* 4		1																						1	SPT - 1
2		SPT		* 26		2																						2	SPT - 2
3		SPT		* 17		3																						3	SPT - 3
4		SPT	**CLAYEY SILT** *Grey, soft to medium stiff, clayey, traces of sand*	* 5		4	ML		5.4	48.6	46	40.9	38.2	2.7														4	SPT - 4
5		SPT		* 3		5																						5	SPT - 5
6		SPT	**SILTY SAND** *Grey, dense, fine to medium grained, silty sand*	* 36		6																						6	SPT - 6
7		SPT	**CLAYEY SILT** *Grey, soft, clayey silt*	* 2		7																						7	SPT - 7
8		SPT	**SAND WITH LITTLE SILT** *Yellowish grey, medium dense to very dense, fine to medium grained, little silt, traces of clay and gravel*	* 11		8																						8	SPT - 8
9		UDS				9	SM	4.8	71.6	14.6	9	NLL	-	NPI	16.7	1.71	2											9	UDS - 1
10		SPT		* 32		10																						10	SPT - 9

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-13

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 29 (m)
GWL: 0.76 (m)
Drill Date: 19.09.2019
Logged By: MA

Elevation: 8.23(m) from MSL
Easting: 307101.2876
Northing: 2747780.1905
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**SAND WITH LITTLE SILT** *Yellowish grey, medium dense to very dense, fine to medium grained, little silt, traces of clay and gravel*	* 32		10																						10	SPT - 9
11		U		* 50		11																						11	SPT - 10
12		U		* 50		12																						12	SPT - 11 SPT Drive - 125mm
13		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, traces of sand*	* 50		13																						13	SPT - 12 SPT Drive - 350mm
14		U		* 50		14	ML		9.4	49.1	41.5	23.5	22.1	1.4														14	SPT - 13 SPT Drive - 200mm
15		U		* 50		15																						15	SPT - 14 SPT Drive - 130mm
16		U		* 50		16																						16	SPT - 15 SPT Drive - 325mm
17		U		* 50		17																						17	SPT - 16 SPT Drive - 125mm
18		U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained, silty sand with traces of clay*	* 50		18																						18	SPT - 17 SPT Drive - 75mm
19						19																						19	
20		U		* 50		20																						20	SPT - 18

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-13

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 29 (m)
GWL: 0.76 (m)
Drill Date: 19.09.2019
Logged By: MA
Elevation: 8.23(m) from MSL
Easting: 307101.2876
Northing: 2747780.1905
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
20		U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained, silty sand with traces of clay*	* 50		20																						20	SPT - 18 SPT Drive - 125mm
21		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, traces of sand*	* 50		21																						21	SPT - 19 SPT Drive - 100mm
22						22																						22	
23		U		* 50		23	ML		1.4	50.5	48.1	34.5	30	4.5														23	SPT - 20 SPT Drive - 75mm
24		U		* 50		24																						24	
25		■ + +	**MUDSTONE** *Grey, very weak, moderately weathered, poor to fair quality of rock*			25									5.5	2.18	2.3							15.39				25	SPT - 21 SPT Drive - 75mm Run - 1 CR - 98% / RQD - 76% UDC - 1 (24.70 - 24.97m)
26		+				26																						26	Run - 2 CR - 96% / RQD - 28% UDC - 2 (26.11 - 26.39m)
27		■ +				27																						27	Run - 3 CR - 100% / RQD - 66%
28						28																						28	UDC - 3 (27.50 - 27.68m)
29			End of Log @ 29 (m)			29																						29	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-14

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 24.09.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 306694.9926
Northing: 2747677.5705
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with sand and gravel*			0																						0	
1	▽	U	**SILTY SAND** *Grey, loose, fine to medium grained sand, silty*	* 5		1																						1	SPT - 1
2		U	**CLAYEY SAND** *Grey, loose, fine to medium grained sand, clayey silt*	* 9		2																						2	SPT - 2
3		U	**SAND SILT** *Grey, medium stiff, sandy silt*	* 7		3																						3	SPT - 3
4		U	**CLAYEY SILT** *Grey, soft, clayey, traces of sand*	* 2		4																						4	SPT - 4
5		U		* 3		5	ML		2	50.3	47.7	26	25	1														5	SPT - 5
6		U	**SAND WITH LITTLE GRAVEL** *Grey, medium dense to dense, fine to coarse grained, little gravel, traces of silt*	* 29		6																						6	SPT - 6
7		U		* 32		7																						7	SPT - 7
8		□				8	SP-SM	18.2	71.8	10		NLL	-	NPI	11.4	1.71	1.9											8	UDS - 1
9		U	**CLAYEY SILT** *Grey, medium stiff, clayey silt with organic material*	* 7		9																						9	SPT - 8
10		U	**(continued ...)**	* 50		10																						10	SPT - 9

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
▽ Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-14

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 24.09.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 306694.9926
Northing: 2747677.5705
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10			**FINE TO COARSE GRAINED SAND** *Blackish grey, very dense, fine to coarse grained sand*	* 50		10																						10	SPT - 9 SPT Drive - 240mm
11			**CLAYEY SILT** *Yellowish brown, very stiff, clayey silt*	* 27		11																						11	SPT - 10
12			**SANDY SILT** *Yellowish grey, hard, sandy silt*	* 50		12																						12	SPT - 11
13				* 50		13																						13	SPT - 12 SPT Drive - 275mm
14			**CLAYEY SILT** *Yellowish brown, hard, clayey, little fine grained sand*	* 50		14																						14	SPT - 13
15				* 33		15																						15	SPT - 14
16				* 50		16	ML		14	46.7	39.3	23.5	20	3.5														16	SPT - 15 SPT Drive - 135mm
17				* 50		17																						17	SPT - 16 SPT Drive - 125mm
18			**SAND WITH TRACES OF SILT** *Yellowish brown, very dense, fine to medium grained, traces of silt*	* 50		18																						18	SPT - 17 SPT Drive - 100mm
19			**CLAYEY SILT** *Yellowish brown, hard, clayey silt, traces of sand*			19																						19	
20				* 50		20																						20	SPT - 18 SPT Drive - 135mm

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-14

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 24.09.2019
Logged By: MA

Elevation: 7.01(m) from MSL
Easting: 306694.9926
Northing: 2747677.5705
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
20			**FINE TO MEDIUM GRAINED SAND** *Grey, very dense, fine to medium grained sand*			20																						20	
21		U		* 50		21																						21	SPT - 19 SPT Drive - 112mm
22		U	**FRIABLE SANDSTONE** *Yellowish grey, very weak, moderately weathered, thickly bedded, very poor to poor quality of rock, interbedded with little clay*	* 50		22																						22	SPT - 20 SPT Drive - 100mm Run - 1 CR - 77% / RQD - Nil
23		■				23																						23	
24		U		* 50		24	SM		68.4	17.4	14.2	NLL	-	NPI														24	SPT - 21 SPT Drive - 75mm Run - 2 CR - 87% / RQD - 10% UDC - 1 (26.41 - 26.51m)
25		■				25																						25	
26		U		* 50		26																						26	SPT - 22 SPT Drive - 75mm Run - 3 CR - 89% / RQD - Nil
27		+				27																						27	
28		U		* 50		28									5.2	1.86	1.96							18.64				28	SPT - 23 SPT Drive - 75mm Run - 4 CR - 94% / RQD - 32% UDC - 2 (27.44 - 27.57m)
29		■				29																						29	
30		U		* 50		30																						30	SPT - 24 SPT Drive - 75mm Run - 5 CR - 92% / RQD - 40% UDC - 3 (29.00 - 29.19m) SPT - 25

End of Log @ 30 (m)

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations:
LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI
C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU)
Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.
w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow
CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-15

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 15.09.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 307180.0788
Northing: 2747819.2190
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0	▽		**FILLING MATERIAL** *Filled with sand and gravel*			0																						0	
1		U	**SILTY SAND** *Yellow, loose to medium dense, fine to medium grained, silty sand*	* 24		1																						1	SPT - 1
2		U		* 8		2																						2	SPT - 2
3		U	**SAND WITH TRACES OF SILT** *Grey, dense, fine to coarse grained, traces of silt*	* 36		3	SP-SM		95	5		NLL	-	NPI														3	SPT - 3
4		U	**CLAYEY SILT** *Blackish grey, soft to medium stiff, clayey silt*	* 5		4																						4	SPT - 4
5		U		* 3		5																						5	SPT - 5
6		U	**SAND WITH SOME SILT** *Grey, dense, fine to medium grained, some silt, traces of clay and gravel*	* 44		6																						6	SPT - 6
7		□				7	SM	1.1	69.7	21	8.2	NLL	-	NPI	12.3	1.74	1.95									0.01	0.15	7	UDS - 1
8			**SANDY SILT** *Grey, stiff to hard, sandy silt*			8																						8	
9		U		* 10		9																						9	SPT - 7
10		U		* 50		10																						10	SPT - 8

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-15

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 15.09.2019
Logged By: MA

Elevation: 7.01(m) from MSL
Easting: 307180.0788
Northing: 2747819.2190
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**SANDY SILT** *Grey, stiff to hard, sandy silt*	* 50		10																						10	SPT - 8
11		U		* 50		11																						11	SPT - 9 SPT Drive - 425mm
12		U	**CLAYEY SILT** *Grey, hard, clayey silt*	* 50		12																						12	SPT - 10 SPT Drive - 125mm
13		U	**SAND WITH LITTLE SILT & GRAVEL** *Grey, very dense, fine to coarse grained, little silt and gravel*	* 50		13																						13	SPT - 11 SPT Drive - 150mm
14		U		* 50		14																						14	SPT - 12 SPT Drive - 125mm
15		U		* 50		15	SP-SM	12.8	77.1	10.1		NLL	-	NPI														15	SPT - 13 SPT Drive - 125mm
16		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, some fine grained sand*	* 50		16																						16	SPT - 14 SPT Drive - 125mm
17		U		* 50		17																						17	SPT - 15 SPT Drive - 150mm
18						18																						18	
19		U		* 50		19																						19	SPT - 16 SPT Drive - 125mm
20						20																						20	

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-15

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 30 (m)
GWL: 0.91 (m)
Drill Date: 15.09.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 307180.0788
Northing: 2747819.2190
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
20		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, some fine grained sand*	* 50		20																						20	SPT - 17 SPT Drive - 125mm
21						21																						21	
22		U		* 50		22	ML		26.6	38.1	35.3	22.3	22	0.3														22	SPT - 18
23						23																						23	SPT Drive - 425mm
24		U		* 50		24																						24	SPT - 19 SPT Drive - 120mm
25		U+■		* 50		25									10.8	2.08	2.3							24.24				25	SPT - 20 Run - 1 CR - 94% / RQD - 48% UDC - 1 (25.30 - 25.63m)
26		■	**MUDSTONE** *Blackish grey, very weak, moderately weathered, very poor to poor quality of rock*			26																						26	Run - 2 CR - 95% / RQD - 20%
27		■+				27																						27	Run - 3 CR - 96% / RQD - 30% UDC - 2 (27.14 - 27.47m)
28		■+				28									8.9	1.95	2.12							13.4				28	Run - 4 CR - 98% / RQD - 26% UDC - 3 (28.33 - 28.46m)
29		■				29																						29	Run - 5 CR - 80% / RQD - Nil
30			End of Log @ 30 (m)			30																						30	

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
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C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
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UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-16

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 40 (m)
GWL: 0.91 (m)
Drill Date: 28.09.2019
Logged By: MA
Elevation: 4.87(m) from MSL
Easting: 306792.2257
Northing: 2747757.3123
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0–1	▽	U	**SILTY SAND** *Yellowish brown, loose, fine to medium grained sand, silty, traces of clay at places*	* 4		0–1																						1	SPT - 1
1–2		U		* 6		1–2																						2	SPT - 2
2–3		U	**CLAYEY SILT** *Grey, soft, clayey silt with organic material*	* 3		2–3																						3	SPT - 3
3–4		U	**SILTY SAND** *Grey, medium dense, fine to medium grained sand, silty*	* 20		3–4																						4	SPT - 4
4–5		U		* 24		4–5																						5	SPT - 5
5–6		□	**SAND WITH TRACES OF SILT & GRAVEL** *Grey, fine to coarse grained, traces of gravel and silt*			5–6	SP	4.9	94.2	0.9		NLL	-	NPI	13.6	1.73	1.97												6	UDS - 1
6–7		U	**CLAYEY SILT** *Grey, stiff, clayey silt with organic material*	* 12		6–7																						7	SPT - 6
7–8		U	**SILTY SAND** *Grey, medium dense to very dense, fine to medium grained sand, silty*	* 14		7–8																						8	SPT - 7
8–9		U		* 28		8–9																						9	SPT - 8
9–10		U		* 45		9–10																						10	SPT - 9

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
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- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-16

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 40 (m)
GWL: 0.91 (m)
Drill Date: 28.09.2019
Logged By: MA

Elevation: 4.87(m) from MSL
Easting: 306792.2257
Northing: 2747757.3123
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**SILTY SAND** *Grey, medium dense to very dense, fine to medium grained sand, silty*	* 45		10																						10	SPT - 9
11		U		* 50		11																						11	SPT - 10 SPT Drive - 262mm
12		U	**SILTY SAND** *Greyish brown, very dense, fine to medium grained sand with silty clay*	* 50		12																						12	SPT - 11 SPT Drive - 262mm
13		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, traces of sand*	* 50		13																						13	SPT - 12 SPT Drive - 125mm
14		U		* 50		14																						14	SPT - 13 SPT Drive - 287mm
15		U		* 50		15	ML		4.6	49	46.4	28.3	22.6	5.7														15	SPT - 14 SPT Drive - 275mm
16		U		* 50		16																						16	SPT - 15 SPT Drive - 250mm
17		U	**SILTY SAND** *Grey, very dense, fine to medium grained, silty, little clay*	* 50		17																						17	SPT - 16 SPT Drive - 275mm
18		U		* 50		18																						18	SPT - 17 SPT Drive - 262mm
19		U		* 50		19																						19	SPT - 18 SPT Drive - 125mm
20						20																						20	

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
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- K : Permeability Coeff.
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Log BH-16

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 40 (m)
GWL: 0.91 (m)
Drill Date: 28.09.2019
Logged By: MA
Elevation: 4.87(m) from MSL
Easting: 306792.2257
Northing: 2747757.3123
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
20		U	**SILTY SAND** *Grey, very dense, fine to medium grained, silty, little clay*	* 50		20	SM		56.8	30.5	12.7	NLL	-	NPI														20	SPT - 19 SPT Drive - 225mm
21						21																						21	
22		U		* 50		22																						22	SPT - 20 SPT Drive - 100mm
23						23																						23	
24		U		* 50		24																						24	SPT - 21 SPT Drive - 112mm
		■																											Run - 1 CR - 98% / RQD - 39% UDC - 1 (24.44 - 24.58m)
25		+	**FRIABLE SANDSTONE** *Grey, very weak, moderately weathered, thickly bedded, very poor to poor quality of rock*			25									6.2	1.87	1.99							17.45				25	
		■																											Run - 2 CR - 96% / RQD - Nil
26		■				26																						26	Run - 3 CR - 94% / RQD - 13% UDC - 2 (26.00 - 26.13m)
27		■				27																						27	Run - 4 CR - 98% / RQD - Nil
28		■				28																						28	Run - 5 CR - 97% / RQD - Nil
29		■				29																						29	Run - 6 CR - 93% / RQD - 11%
30		■				30																						30	Run - 7

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
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Log BH-16

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 40 (m)
GWL: 0.91 (m)
Drill Date: 28.09.2019
Logged By: MA

Elevation: 4.87(m) from MSL
Easting: 306792.2257
Northing: 2747757.3123
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
30		■	**FRIABLE SANDSTONE** *Grey, very weak, moderately weathered, thickly bedded, very poor to poor quality of rock*			30																						30	Run - 7 CR - 92% / RQD - Nil
31		+ ■				31									10.2	1.78	1.96							20.78				31	Run - 8 CR - 73% / RQD - 25% UDC - 3 (31.27 - 31.39m)
32		■				32																						32	Run - 9 CR - 70% / RQD - 13% UDC - 4 (32.54 - 32.67m)
33						33																						33	
34		■				34																						34	Run - 10 CR - 25% / RQD - Nil
35		■				35																						35	Run - 11
36		■				36																						36	CR - 30% / RQD - Nil Run - 12 CR - 28% / RQD - Nil
37		■				37																						37	Run - 13 CR - 86% / RQD - Nil
38		■				38																						38	Run - 14 CR - 90% / RQD - Nil Run - 15 CR - 85% / RQD - Nil
39		■				39																						39	Run - 16 CR - 77% / RQD - Nil
40			End of Log @ 40 (m)			40																						40	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-17

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 12 (m)
GWL: 1.52 (m)
Drill Date: 04.08.2019
Logged By: SH
Elevation: 6.70(m) from MSL
Easting: 305818.7149
Northing: 2747619.4863
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with bricks and gravels*			0																						0	
1	▽	U	**MICACEOUS FINE GRAINED SAND** *Grey, medium dense, micaceous, fine grained SAND*	* 26		1																						1	SPT - 1
2		U		* 17		2																						2	SPT - 2
3		U	**SILTY CLAY** *Grey, soft, silty, little sand*	* 4		3																						3	SPT - 3
4		U		* 3		4																						4	SPT - 4
5		U		* 3		5	CL		10.6	40.1	49.3	22.4	15	7.4														5	SPT - 5
6		U	**CLAYEY SILT** *Blackish grey, very soft to hard, clayey SILT with organic material at places*	* 1		6																						6	SPT - 6
7		U		* 1		7																						7	SPT - 7
8		U		* 4		8																						8	SPT - 8
9		U		* 4		9																						9	SPT - 9
10		U		* 4		10																						10	SPT - 10

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
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- F : Fast
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- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-17

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 12 (m)
GWL: 1.52 (m)
Drill Date: 04.08.2019
Logged By: SH
Elevation: 6.70(m) from MSL
Easting: 305818.7149
Northing: 2747619.4863
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**CLAYEY SILT** *Blackish grey, very soft to hard, clayey SILT with organic material at places*	* 4		10																						10	SPT - 10
11		U		* 31		11																						11	SPT - 11
12		U	**SAND WITH LITTLE SILT** *Grey, very dense, fine to medium grained, little silt, traces of gravel*	* 50		12	SP-SM	0.6	88.3	11.1		NLL	-	NPI														12	SPT - 12
			End of Log @ 12 (m)																										

Sample Types: Disturbed; Undisturbed; Shelby / U4; Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations:
LL : Liquid Limit
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NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-18

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 18 (m)
GWL: 0.61 (m)
Drill Date: 24.08.2019
Logged By: MA

Elevation: 9.45(m) from MSL
Easting: 304921.3548
Northing: 2749157.3324
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0	▽		**FILLING MATERIAL** *Grey, soft to stiff, clayey silt*			0																						0	
1		U	**CLAYEY SILT** *Grey, soft to stiff, clayey, little sand*	* 4		1																						1	SPT - 1
2		U		* 5		2																						2	SPT - 2
3		U		* 4		3	ML		14.6	44.2	41.2	39.2	34.7	4.5														3	SPT - 3
4		U		* 9		4																						4	SPT - 4
5		U	**SILTY CLAY** *Grey, very soft to soft, silty clay with organic material*	* 3		5																						5	SPT - 5
6		U		* 1		6																						6	SPT - 6
7		U		* 2		7																						7	SPT - 7
8		U	**PIECES OF LIMESTONE** *Yellowish brown, highly weathered and fractured, very poor quality of pieces of rock, interbedded with silty sandy, some clay and gravel at places*	* 50		8																						8	SPT(C) - 1
9		U		* 50		9	ML		39.6	38.2	22.2	NLL	-	NPI														9	SPT - 8
10		U		* 50		10																						10	SPT(C) - 3

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-18

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 18 (m)
GWL: 0.61 (m)
Drill Date: 24.08.2019
Logged By: MA
Elevation: 9.45(m) from MSL
Easting: 304921.3548
Northing: 2749157.3324
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**PIECES OF LIMESTONE** *Yellowish brown, highly weathered and fractured, very poor quality of pieces of rock, interbedded with silty sandy, some clay and gravel at places*	* 50		10																						10	SPT(C) - 3
11		U		* 50		11																						11	SPT(C) - 4
12		U		* 50		12																						12	SPT(C) - 5
13		U		* 50		13																						13	SPT(C) - 6
14		U / ■	**MUDSTONE** *Blackish grey, moderately weathered, very poor quality of rock*	* 50		14																						14	SPT(C) - 7 Run - 1 CR - 90% / RQD - Nil
15		■				15																						15	Run - 2 CR - 60% / RQD - Nil
16		■				16																						16	Run - 3 CR - 70% / RQD - Nil
17		■				17																						17	Run - 4 CR - 57% / RQD - Nil
18			End of Log @ 18 (m)			18																						18	

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-19

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL: 5.03 (m)
Drill Date: 04.08.2019
Logged By: SH
Elevation: 15.84(m) from MSL
Easting: 304058.7409
Northing: 2748668.9782
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with sand and gravel*	* 50		0																						0	
1		U	**SANDY SILT** *Yellowish brown, hard, sandy, interbedded with thin layer of clay*	* 50		1																						1	SPT - 1 SPT Drive - 450mm
2		U		* 50		2																						2	SPT - 2 SPT Drive - 250mm
3		U	**SILTY SAND** *Yellowish brown, very dense, fine to coarse grained, silty, little clay, traces of gravel*	* 50		3	SM	2.9	53.6	32.8	10.7	NLL	-	NPI														3	SPT - 3 SPT Drive - 400mm
4		U	**GRAVEL WITH SILTY SAND** *Yellowish brown, very dense, pieces of friable sandstone with silty sand*	* 50		4																						4	SPT(C) - 1 SPT Drive - 75mm
5	▽	U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained, silty SAND with traces to some clay*	* 50		5																						5	SPT - 4 SPT Drive - 135mm
6		U		* 50		6																						6	SPT - 5 SPT Drive - 125mm
7		U		* 50		7																						7	SPT - 6 SPT Drive - 125mm
8		U		* 50		8																						8	SPT - 7 SPT Drive - 75mm
9		U		* 50		9																						9	SPT(C) - 2 SPT Drive - 75mm
10		U	End of Log @ 10 (m)	* 50		10																						10	SPT - 8

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-20

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 12 (m)
GWL: -Not Encountered
Drill Date: 29.08.2019
Logged By: MA
Elevation: 22.55(m) from MSL
Easting: 303510.0586
Northing: 2749158.7743
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Road Filled material with aggregate base course*			0																						0	
1		U	**SILTY SAND** *Grey, fine to medium grained, silty sand*	* 13		1																						1	SPT - 1 SPT Drive - 320mm
2		U	**SAND WITH SOME SILT & TRACES OF CLAY** *Yellowish brown, medium dense to very dense, fine to medium grained, some silt, traces of clay*	* 50		2	SM		66.9	24.1	9	NLL	-	NPI														2	SPT - 2 SPT Drive - 240mm
3		U		* 50		3																						3	SPT - 3 SPT Drive - 100mm
4		U		* 50		4																						4	SPT - 4 SPT Drive - 180mm
5		U		* 50		5																						5	SPT - 5 SPT Drive - 200mm
6		□	**SILT WITH SOME SAND & CLAY** *Yellowish brown, some fine grained sand, some clay*	* 50		6	ML		23.5	53	23.5	NLL	-	NPI	15.3	1.69	1.95									0.02	0.12	6	UDS - 1
7		U	**SAND WITH LITTLE SILT** *Yellowish brown, very dense, fine to medium grained, little silt*	* 50		7																						7	SPT - 6 SPT Drive - 180mm
8		U		* 50		8																						8	SPT - 7 SPT Drive - 120mm
9		U	**SILTY GRAVEL** *Yellowish grey, very dense, gravels with silty sand, traces of clay*	* 50		9																						9	SPT(C) - 1 SPT Drive - 100mm
10		U		* 50		10																						10	SPT(C) - 2

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-20

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 12 (m)
GWL: -Not Encountered
Drill Date: 29.08.2019
Logged By: MA
Elevation: 22.55(m) from MSL
Easting: 303510.0586
Northing: 2749158.7743
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**SILTY GRAVEL** *Yellowish grey, very dense, gravels with silty sand, traces of clay*	* 50		10																						10	SPT(C) - 2 SPT Drive - 100mm
11		U	**SILTY SAND** *Yellowish brown, very dense, fine to medium grained silty sand with fine layer of clay, traces of gravel*	* 50		11																						11	SPT(C) - 3 SPT Drive - 125mm
12		U	**SAND WITH LITTLE SILT** *Yellowish brown, very dense, fine to medium grained, little silt*	* 50		12	SP-SM		88.2	11.8		NLL	-	NPI														12	SPT - 8 SPT Drive - 180mm
			End of Log @ 12 (m)																										

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-21

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL: 2.5 (m)
Drill Date: 05.09.2019
Logged By: MA
Elevation: 19.81(m) from MSL
Easting: 303160.1063
Northing: 2750213.1914
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with yellowish brown, medium stiff, fine grained, sandy, clayey silt*			0																						0	
1		U		* 7		1																						1	SPT - 1
2	▽	U	**CLAY WITH SILT & SAND** *Yellowish brown, stiff, silty sandy clay*	* 10		2																						2	SPT - 2
3		U	**CLAYEY SILT** *Yellowish brown, hard, clayey, traces of sand*	* 40		3																						3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		□				5	ML		6.7	48	45.3	48.9	37.5	11.4	17.3	1.67	1.96				0.34	0.03	1.5	1.09				5	UDS - 1
6		U	**SAND WITH SOME SILT** *Yellowish brown, dense to very dense, fine grained, some silt, traces of clay and gravel*	* 39		6																						6	SPT - 5
7		U		* 50		7																						7	SPT - 6
8		U		* 50		8																						8	SPT - 7
9		U		* 50		9	SM	4.5	57.3	29.3	8.9	NLL	-	NPI														9	SPT - 8 SPT Drive - 400mm
10		U		* 50		10																						10	SPT - 9

End of Log @ 10 (m)

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-22

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 04.10.2019
Logged By: MA
Elevation: 18.28(m) from MSL
Easting: 303555.4038
Northing: 2750813.7539
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		U	**FILLING MATERIAL** *Filled with grey, loose to medium dense, fine to coarse grained sand with silt*			0																						0	
1		U		* 26		1																						1	SPT - 1
2		U	**SANDY CLAY** *Yellowish brown, medium stiff to hard, fine to medium grained sandy, silty clay*	* 7		2																						2	SPT - 2
3		U		* 50		3																						3	SPT - 3 SPT Drive - 375mm
4		U	**SAND WITH SOME SILT** *Brownish yellow, very dense, fine to medium grained, some silt, little clay with some gravel*	* 50		4	SM		57.4	28.4	14.2	NLL	-	NPI														4	SPT - 4 SPT Drive - 125mm
5		U		* 50		5																						5	SPT - 5 SPT Drive - 125mm
6		U		* 50		6																						6	SPT - 6 SPT Drive - 137mm
7		U		* 50		7																						7	SPT - 7 SPT Drive - 75mm
8		■	**MUDSTONE** *Blackish grey, very weak, moderately weathered, very poor to good quality of rock*			8									1.3	2.48	2.51							44.87				8	Run - 1 CR - 80% / RQD - Nil Run - 2 CR - 86% / RQD - 39% UDC - 2 (8.31 - 8.56m)
9		■				9																						9	Run - 3 CR - 100% / RQD - 78% UDC - 3 (9.00 - 9.78m)
10			End of Log @ 10 (m)			10																						10	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-23

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 14 (m)
GWL: -Not Encountered
Drill Date: 06.08.2019
Logged By: SH
Elevation: 22.55(m) from MSL
Easting: 303349.5211
Northing: 2751533.2125
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Road Filling*			0																						0	
1		U	**SILTY SAND** *Yellowish brown, loose, fine to medium grained SAND, silty with traces of gravel*	* 9		1																						1	SPT - 1
2		U	**SANDY SILT** *Yellow, very stiff to hard, sandy SILT, traces of clay*	* 28		2																						2	SPT - 2
3		U	**CLAY / SILT** *Yellow, hard, clayey silt/ silty clay, little fine grained sand*	* 50		3																						3	SPT - 3
4		U		* 50		4	CL-ML		12.6	42.9	44.5	28.5	21.7	6.8															4	SPT - 4 SPT Drive - 450mm
5		U		* 50		5																						5	SPT - 5 SPT Drive - 150mm
6		U		* 50		6																						6	SPT - 6 SPT Drive - 200mm
7		U ■		* 50		7																						7	SPT - 7 SPT Drive - 225mm Run - 1 CR - 80% / RQD - Nil
8		U ■ +	**CLAYSTONE** *Yellowish brown, extremely weak, modertely weathered, poor quality of rock*	* 50		8																						8	SPT(C) - 1 SPT Drive - 25mm Run - 2 CR - 93% / RQD - 37% UDC - 1 (8.50 - 8.73m)
9		U ■ +		* 50		9																		3.68				9	SPT(C) - 2 SPT Drive - 25mm Run - 3 CR - 95% / RQD - 30% UDC - 2 (9.30 - 9.48m)
10		U		* 50		10																						10	SPT(C) - 3

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-23

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 14 (m)
GWL: -Not Encountered
Drill Date: 06.08.2019
Logged By: SH
Elevation: 22.55(m) from MSL
Easting: 303349.5211
Northing: 2751533.2125
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50 * 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**MUDSTONE** *Balckish grey, very weak, hghly weathered, poor to fair quality of rock*			10																						10	SPT(C) - 3 SPT Drive - 25mm Run - 4 CR - 90% / RQD - 40% UDC - 3 (10.50 - 10.66m)
11		+				11																						11	Run - 5 CR - 96% / RQD - 56% UDC - 4 (11.45 - 11.78m)
12		■				12																		34.91				12	Run - 6 CR - 97% / RQD - 64% UDC - 5 (12.49 - 12.76m)
13		+				13																						13	Run - 7 CR - 97% / RQD - 68% UDC - 6 (13.06 - 13.22m)
14		■	End of Log @ 14 (m)			14																						14	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-24

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 26.05.2019
Logged By: SH
Elevation: 32.0(m) from MSL
Easting: 319063.58
Northing: 2749518.85
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**Fill Material** *Filled with concrete*			0																						0	
1		U	**SAND WITH SOME GRAVEL** *Yellowish brown, very dense, fine to coarse grained, some gravel, little silt*	* 50		1																						1	SPT - 1
2		U		* 50		2																						2	SPT - 2 SPT Drive - 250mm
3		U		* 50		3	SW-SM	24.1	64.9	11		NLL	-	NPI												0.01	0.11	3	SPT - 3 SPT Drive - 250mm
4		U		* 50		4																						4	SPT - 4 SPT Drive - 125mm
5		U		* 50		5																						5	SPT - 5 SPT Drive - 50mm
6		U	**SAND WITH GRAVELS** *Yellowish brown, very dense, fine to coarse grained SAND with gravels*	* 50		6																						6	SPT(C) - 1 SPT Drive - 50mm
7		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND, traces of gravel*	* 50		7																						7	SPT(C) - 2 SPT Drive - 275mm
8		U	**SILTY SAND** *Greyish yellow, very dense, fine to coarse grained SAND with silty clay*	* 50		8																						8	SPT - 6 SPT Drive - 225mm Run - 1
9		■	**CLAYSTONE** *Brownish grey, extremely weak, moderately weathered, very poor quality of rock*			9									12.4	1.99	2.24							4.99				9	CR - 27% / RQD - 22% UDC - 1 (8.40 - 8.61m) SPT - 7 SPT Drive - 275mm Run - 2
10		U		* 50		10																						10	CR - 100% / RQD - Nil SPT - 8

End of Log @ 10 (m)

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-25

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 10 (m)
GWL:- Not Encountered
Drill Date: 28.05.2019
Logged By: SH
Elevation: 32.0(m) from MSL
Easting: 309580.20
Northing: 2746129.34
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with concrete*			0																						0	
1		U	**SAND WITH TRACES OF SILT & GRAVEL** *Yellowish brown, dense, fine to coarse grained, traces of silt and gravel*	* 36		1																						1	SPT - 1
2		U		* 32		2	SP-SM	2.5	91.5	6		NLL	-	NPI														2	SPT - 2
3		U	**SAND WITH TRACES OF GRAVEL** *Yellowish brown, very dense, fine to coarse grained SAND with traces of gravel*	* 50		3																						3	SPT - 3
4		U		* 50		4																						4	SPT - 4 SPT Drive - 250mm
5		U		* 50		5																						5	SPT - 5 SPT Drive - 100mm
6		U		* 50		6																						6	SPT - 6 SPT Drive - 25mm
7		U		* 50		7																						7	SPT - 7 SPT Drive - 25mm
8		U ■	**CLAYSTONE** *Reddish brown, extremely weak, moderately weathered, very poor quality of rock, interbedded with some fine grained sand*	* 50		8									11.2	2.05	2.28							7.07				8	SPT - 8 SPT Drive - 200mm Run - 1 CR - 42% / RQD - 24% UDC - 1 (8.24 - 8.60m)
9		U ■		* 43		9																						9	SPT - 9 Run - 2 CR - 60% / RQD - Nil
10		U	End of Log @ 10 (m)	* 50		10																						10	SPT - 10

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log BH-26

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 11 (m)
GWL: 2.5 (m)
Drill Date: 08.09.2019
Logged By: MA
Elevation: 7.92(m) from MSL
Easting: 309580.200
Northing: 2746129.340
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with concrete, sand and gravel*			0																						0	
1		U	**SILTY SAND** *Yellowish brown, loose to medium dense, fine to medium grained, silty sand*	* 6		1																						1	SPT - 1
2	▽	U		* 20		2																						2	SPT - 2
3		U		* 19		3																						3	SPT - 3
4		U	**SAND WITH TRACES OF SILT** *Yellowish brown, medium dense, fine to coarse grained, traces of silt*	* 24		4	SP-SM		92.2	7.8		NLL	-	NPI														4	SPT - 4
5		U		* 11		5																						5	SPT - 5
6		U	**CLAY / SILT** *Grey, soft, clayey silt/silty clay with little to some sand*	* 2		6																						6	SPT - 6
7		U		* 3		7																						7	SPT - 7
8		U		* 4		8																						8	SPT - 8
9		U	**SILTY SAND** *Grey, medium dense, fine grained silty sand*	* 21		9																						9	SPT - 9
10		U	**CLAYEY SILT** *Grey, hard, clayey, little sand*	* 38		10	ML		16.6	45	38.4	46	31.5	14.5														10	SPT - 10

Sample Types
● Disturbed
+ Undisturbed
□ Shelby / U4
■ Core Cutter
SPT Sample
Water Sample
▽ Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log BH-26

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 11 (m)
GWL: 2.5 (m)
Drill Date: 08.09.2019
Logged By: MA
Elevation: 7.92(m) from MSL
Easting: 309580.200
Northing: 2746129.340
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**CLAYEY SILT** *Grey, hard, clayey, little sand*	* 38		10	ML		16.6	45	38.4	46	31.5	14.5														10	SPT - 10
11		U	End of Log @ 11 (m)	* 50		11																						11	SPT - 11

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
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- CU : Consolidated, Undrained

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Log BH-27

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 12 (m)
GWL: 2.5 (m)
Drill Date: 06.09.2019
Logged By: MA
Elevation: 7.01(m) from MSL
Easting: 309537.500
Northing: 2746079.97
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with concrete, fine sand and gravel*			0																						0	
1		U	**CLAYEY SILT** *Yellowish brown, soft, clayey silt*	* 3		1																						1	SPT - 1
2	▽	U	**SAND WITH TRACES OF SILT** *Yellowish brown, medium dense, fine to coarse grained, traces of silt*	* 20		2																						2	SPT - 2
3		U		* 20		3	SP-SM		90.7	9.3		NLL	-	NPI														3	SPT - 3
4		U	**CLAYEY SILT** *Grey, soft, clayey silt*	* 3		4																						4	SPT - 4
5		U	**SILTY SAND** *Grey, medium dense, fine to medium grained silty sand*	* 11		5																						5	SPT - 5
6		U	**CLAYEY SILT** *Grey, soft, clayey silt*	* 2		6																						6	SPT - 6
7		U	**SILTY SAND** *Grey, medium dense, fine to medium grained silty sand*	* 12		7																						7	SPT - 7
8		U	**SAND WITH SOME SILT** *Grey, loose to medium dense, fine grained, some silt, little clay*	* 5		8	SM		60.6	22.5	16.9	NLL	-	NPI														8	SPT - 8
9		U		* 21		9																						9	SPT - 9
10		U		* 22		10																						10	SPT - 10

Sample Types
- ● Disturbed
- + Undisturbed
- □ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log BH-27

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 12 (m)
GWL: 2.5 (m)
Drill Date: 06.09.2019
Logged By: MA

Elevation: 7.01(m) from MSL
Easting: 309537.500
Northing: 2746079.97
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO4	CL	Depth (m)	Remarks & Comments
10		U	**SILTY SAND** *Grey, medium dense to very dense, fine to medium grained silty sand*	* 22		10																						10	SPT - 10
11		U		* 50		11																						11	SPT - 11 SPT Drive - 75mm
12		U	End of Log @ 12 (m)	* 50		12																						12	SPT - 12 SPT Drive - 125mm

Sample Types: Disturbed; Undisturbed; Shelby / U4; Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-01

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 19.20(m) from MSL
Easting: 315845.9719
Northing: 2749539.4965
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt Layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Greyish brown Gravel, fine to coarse grained sandy, traces of silt*				GP-GM	48	43	9		NLL	-	NPI															DS - 2
			SANDY SILT *Yellowish brown, fine grained sandy, silt with little clay*																										
1		●				1	ML		46.6	34.3	19.1	NLL	-	NPI														1	DS - 3
2			End of Log @ 2 (m)			2																						2	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-02

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 12.19(m) from MSL
Easting: 314490.0578
Northing: 2749265.7051
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**FILLING MATERIAL** *Filled with asphalt layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Filled with aggregate base course*																										DS - 2
		●	**CLAYEY SILT** *Yellowish brown, clayey silt with gravel and pieces of boulders*																										DS - 3
1		●	**SAND WITH TRACES OF SILT, CLAY & GRAVEL** *Yellowish brown, fine to medium grained sand, traces of silt, clay and gravel*			1	SM	0.8	83.5	8.9	6.8	NLL	-	NPI														1	DS - 4
2			End of Log @ 2 (m)			2																						2	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-03

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 13.10(m) from MSL
Easting: 313398.4469
Northing: 2749039.8281
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Filled with aggregate base course material*																										DS - 2
		●	**CLAYEY SILT** *Yellowish brown, clayey silt with gravels*																										DS - 3
1			**SANDY SILT** *Yellowish brown, fine grained sandy, some silt and clay*			1																						1	
		●					ML		48.7	29.4	21.9	NLL	-	NPI															DS - 4
2			End of Log @ 2 (m)			2																						2	

Sample Types
● Disturbed
+ Undisturbed
☐ Shelby / U4
■ Core Cutter
SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log TP-04

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 11.27(m) from MSL
Easting: 311809.9317
Northing: 2748721.3173
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**FILLING MATERIAL** *Filled with asphalt layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Greyish brown Gravel, fine to coarse grained sandy, traces of silt*				GW-GM	63	32	5		NLL	-	NPI															DS - 2
			SANDY SILT *Yellowish brown, fine grained sandy, silt with some clay*																										
1		●				1	ML		31.1	44.5	24.5	NLL	-	NPI														1	DS - 3
2			End of Log @ 2 (m)			2																						2	

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log TP-05

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 7.31(m) from MSL
Easting: 310634.1017
Northing: 2748479.3777
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Greyish brown Gravel, fine to coarse grained sandy, traces of silt*				GP-GM	56	38	6		NLL	-	NPI															DS - 2
			CLAYEY SILT *Yellowish brown, clayey silt, traces of sand*																										
1		●				1	ML		2.3	50.1	47.6	14.1	11	3.1														1	DS - 3
2			End of Log @ 2 (m)			2																						2	

Sample Types
● Disturbed
+ Undisturbed
☐ Shelby / U4
■ Core Cutter
SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Compression qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

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Log TP-06

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 10.10.2019
Logged By: OR
Elevation: 7.62(m) from MSL
Easting: 309336.5402
Northing: 2748205.6524
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*	10 20 30 40 50		0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Filled with aggregate base course*																										DS - 2
		●	**SAND WITH SOME SILT** *Yellowish brown, fine to medium grained, some silt, little clay and gravel*				SM	14.6	43.9	25.1	16.4	NLL	-	NPI															DS - 3
1		●	**ASPHALT LAYER** *Filled with old asphalt layer*			1																						1	DS - 4
		●	**GRAVEL WITH SAND** *Brown, fine to coarse sand with gravel*																										DS - 5
		●	**ASPHALT LAYER** *Filled with old asphalt layer*																										DS - 6
2		●	**SAND WITH GRAVEL** *Yellowish brown, medium to coarse sand with gravel*			2																						2	DS - 7
			End of Log @ 2 (m)																										

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-07

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 20.09.2019
Logged By: OR
Elevation: 9.14(m) from MSL
Easting: 307917.6323
Northing: 2747912.7095
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*			0																						0	DS - 1
		●	**WATER BOUND MATERIAL** *Grey Gravel, fine to coasre grained sandy, traces of silt*				GP-GM	55	39	6		NLL	-	NPI															DS - 2
			SAND WITH LITTLE SILT *Yellowish brown, fine to medium grained, little silt, traces of gravel and clay*																										
1		●				1	SM	2.2	84	10.2	3.6	NLL	-	NPI														1	DS - 3
2			End of Log @ 2 (m)			2																						2	

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Compression qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

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Log TP-09

Project Info.
Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.
Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 07.10.2019
Logged By: OR
Elevation: 6.70(m) from MSL
Easting: 306305.7977
Northing: 2747599.2977
Rev. BY: FA

Company Info.
SOIL TESTING SERVICES
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www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPAHLAT LAYER** *Filled with asphalt*			0																						0	DS - 1
		●	**WATER BOUND MACADAM** *Filled with coarse aggregate*																										DS - 2
			SAND WITH GRAVEL *Yellowish brown, fine to medium grained sand with gravel, traces of silt*																										DS - 3
1		●	**ASPAHLAT LAYER** *Filled with old asphalt layer*			1																						1	DS - 4
		●	**SAND WITH GRAVEL** *Yellowish brown, fine to medium grained sand with gravel, traces of silt*																										DS - 5
2		●	**SILTY SAND** *Yellowish brown, fine gained silty sand*			2																						2	DS - 6
			End of Log @ 2 (m)																										

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-10

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.2 (m)
GWL: 1.2 (m)
Drill Date: 05.10.2019
Logged By: OR

Elevation: 10.05(m) from MSL
Easting: 305059.6543
Northing: 2748059.8175
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt*			0																						0	DS - 1
		●	**WATER BOUND MATERIAL** *Filled with coarse aggregate*																										DS - 2
		●	**SAND WITH GRAVEL** *Greyish, fine to coarse grained sand with gravel and pieces of boulders*																										DS - 3
		●																											DS - 4
1	▽	●	**ASPHALT LAYER** *Filled with old asphalt layer*			1																						1	DS - 5
		●	**SAND WITH GRAVEL** *Greyish, fine to coarse grained sand with gravel and pieces of boulders*																										DS - 6
			End of Log @ 1.2 (m)																										

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-11

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.1 (m)
GWL: 1.1 (m)
Drill Date: 06.10.2019
Logged By: OR

Elevation: 11.88(m) from MSL
Easting: 304341.6114
Northing: 2748473.5889
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with Asphalt layer*	10 20 30 40 50		0																						0	DS - 1
		●	**WATER BOUND MATERIAL** *Grey Gravel, some fine to coarse grained sand, traces of silt*				GW-GM	64	28	8		NLL	-	NPI															DS - 2
		●	**GRAVELLY SAND** *Yellowish brown, fine to coarse grained, gravelly, traces of sand*				SP-SM	36.9	58	5.1		NLL	-	NPI															DS - 3
1	▽		End of Log @ 1.1 (m)			1																						1	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-12

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.2 (m)
GWL: -Not Encountered
Drill Date: 07.10.2019
Logged By: OR
Elevation: 20.72(m) from MSL
Easting: 303252.4682
Northing: 2749880.5053
Rev. BY: FA

Company Info.

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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt*	10 20 30 40 50		0																						0	DS - 1
		●	**WATER BOUND MATERIAL** *Filled with coarse aggregate*																										DS - 2
		●	**SANDY SILT** *Yellowish brown, fine grained sandy, some clay, traces of gravel*																										DS - 3
1			End of Log @ 1.2 (m)			1																						1	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-13

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 07.10.2019
Logged By: OR
Elevation: 17.06(m) from MSL
Easting: 303727.5643
Northing: 2750837.0644
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*			0																						0	DS - 1
		●	**WATER BOUND MATERIAL** *Filled with coarse aggregate*																										DS - 2
		●	**CLAYEY SILT** *Yellowish brown, clayey silt, little sand with gravel and boulders*																										DS - 3
1		●	**CLAYEY SILT** *Yellowish brown, clayey silt, traces to little sand*			1																						1	DS - 4
2			End of Log @ 2 (m)			2																						2	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-14

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 2 (m)
GWL: -Not Encountered
Drill Date: 08.10.2019
Logged By: OR
Elevation: 19.05(m) from MSL
Easting: 303585.4524
Northing: 2751350.7985
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**ASPHALT LAYER** *Filled with asphalt layer*			0																						0	DS - 1
		●	**AGGREGATE BASE COURSE** *Filled with aggregate base course*																										DS - 2
			SAND WITH GRAVEL																										
		●	*Yellowish brown, fine to medium grained sand with gravel*																										DS - 3
1			**CLAYEY SILT** *Yellowish brown, clayey silt, traces to little fine grained sand*			1																						1	
		●																											DS - 4
2			End of Log @ 2 (m)			2																						2	

Sample Types: ● Disturbed; + Undisturbed; □ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-15

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.7 (m)
GWL: -Not Encountered
Drill Date: 16.09.2019
Logged By: OR

Elevation: 32.0(m) from MSL
Easting: 319079.07
Northing: 2749545.46
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
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www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**FILLING MATERIAL** *Filled with cement concrete*			0																						0	
1		●	**SAND WITH SOME GRAVEL & LITTLE SILT** *Yellowish brown, fine to coarse grained sand, some gravel, little silt*			1	SM	23	64.5	12.5		NLL	-	NPI														1	DS - 1
			End of Log @ 1.7 (m)																										

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-16

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.4 (m)
GWL: -Not Encountered
Drill Date: 16.09.2019
Logged By: OR
Elevation: 32.3(m) from MSL
Easting: 319100.36
Northing: 2749471.20
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**FILLING MATERIAL** *Filled with cement concrete*	10 20 30 40 50		0																						0	
			SANDY GRAVEL *Yellowish brown, fine to coarse grained sandy, traces of silt*				GP	53.4	42.4	4.2		NLL	-	NPI															DS - 1
1			End of Log @ 1.4 (m)			1																						1	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-17

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.1 (m)
GWL: -Not Encountered
Drill Date: 19.09.2019
Logged By: OR

Elevation: 5.79(m) from MSL
Easting: 309513.08
Northing: 2745907.55
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**SAND WITH TRACES OF SILT** *Yellowish brown, fine to coarse grained sand, traces of silt*			0	SP-SM		91.6	8.4		NLL	-	NPI														0	DS - 1
1			End of Log @ 1.1 (m)			1																						1	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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Log TP-18

Project Info.

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Location : Korangi, Karachi
Job No.: K19-1092-101

Borehole Info.

Depth: 1.5 (m)
GWL: -Not Encountered
Drill Date: 19.09.2019
Logged By: OR

Elevation: 6.40(m) from MSL
Easting: 309570.81
Northing: 2748029.40
Rev. BY: FA

Company Info.

SOIL TESTING SERVICES
Geotechnical Engineering & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Filed Tests (* SPT)	Symbol	Depth (m)	USCS	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Aterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Unit Weight (gr/cm3): Dry	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	Consolidation: Cc	Cs	Pc (kg/cm2)	qu (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0		●	**SAND WITH LITTLE SILT & TRACES OF GRAVEL** *Dark brown, fine to coarse grained sand, little silt, traces of gravel*	10 20 30 40 50		0	SM	0.1	85.8	14		NLL	-	NPI														0	DS - 1
1			End of Log @ 1.5 (m)			1																						1	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Compression qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

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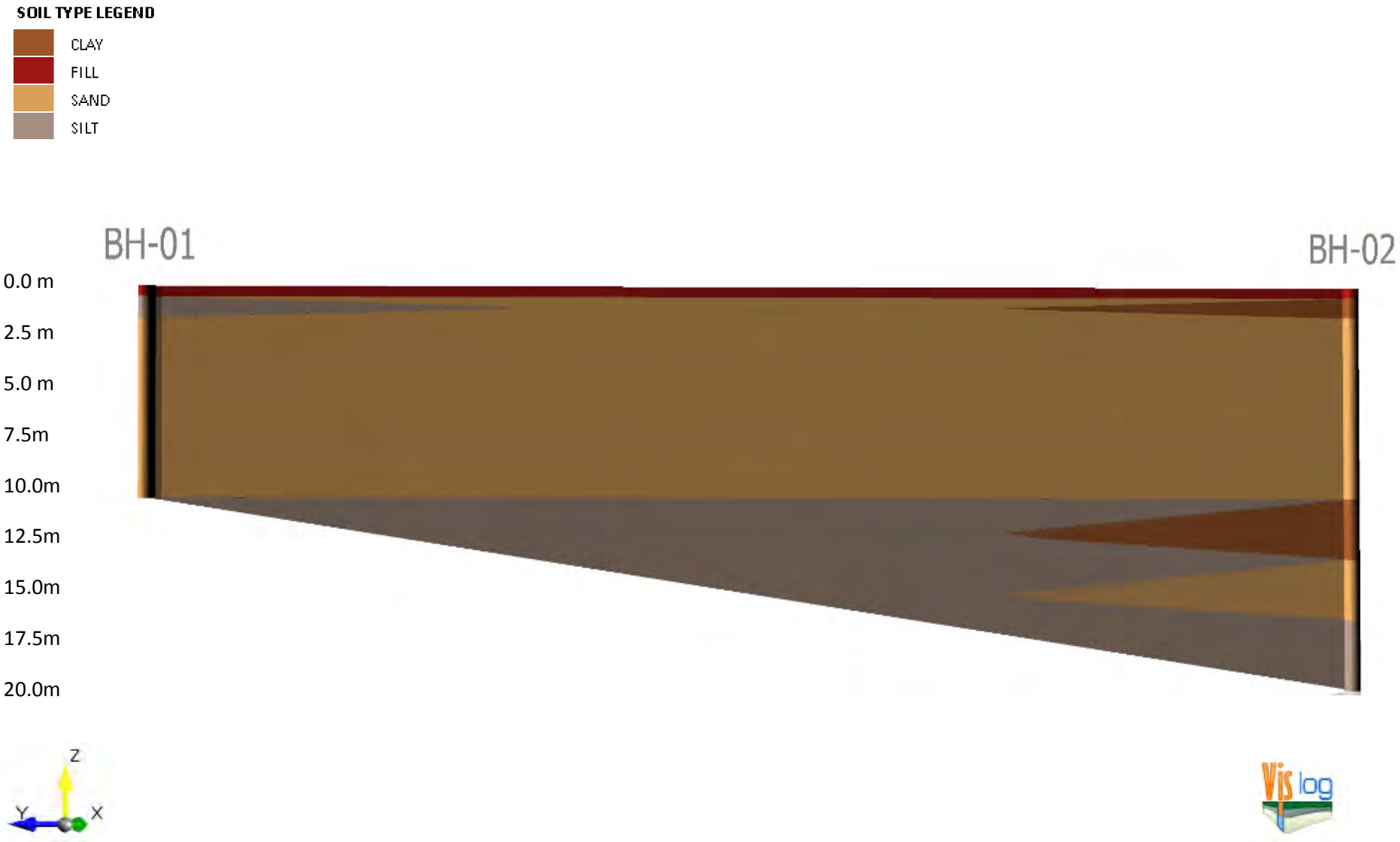
Appendix C

Soil Profiles

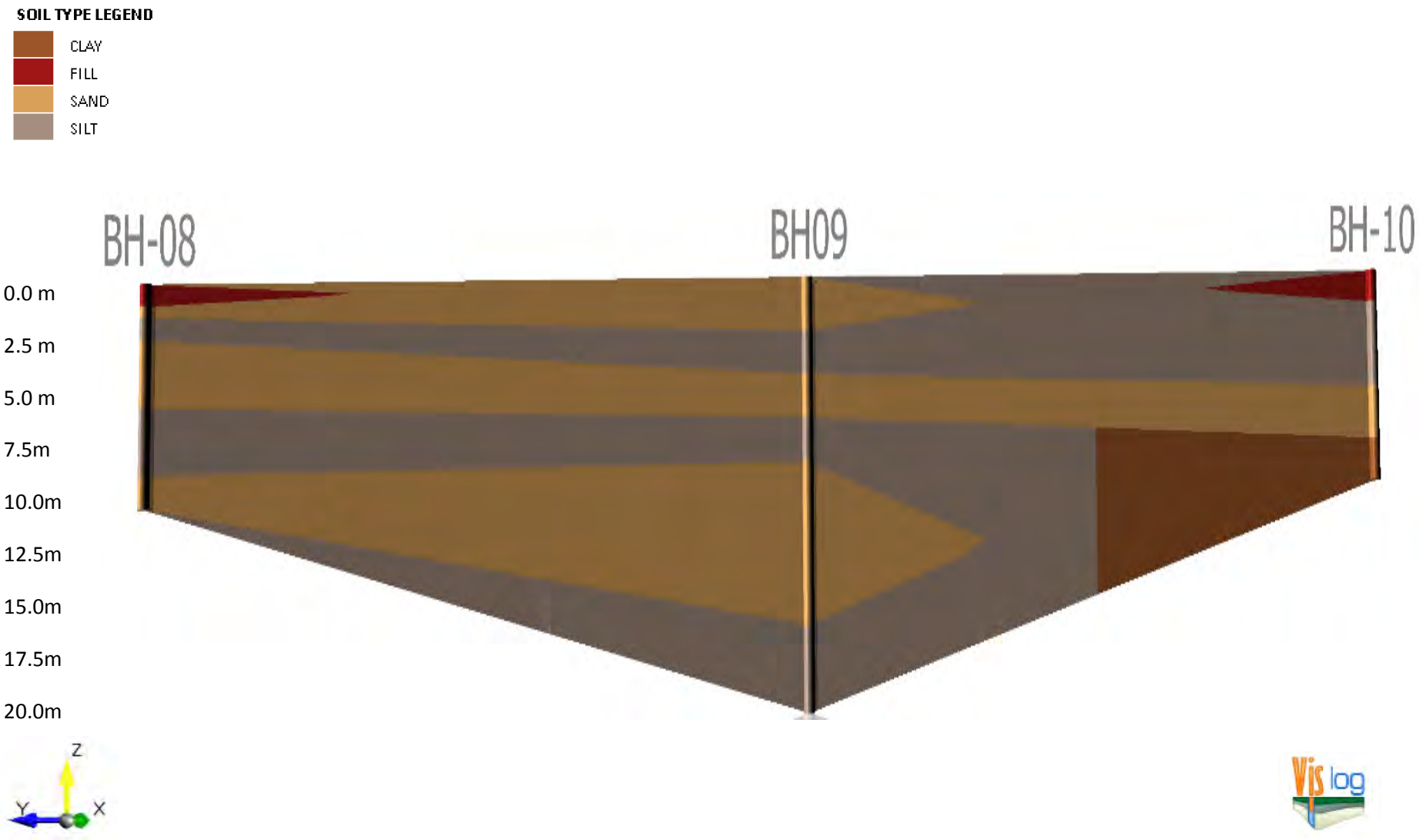
Soil Profile-01



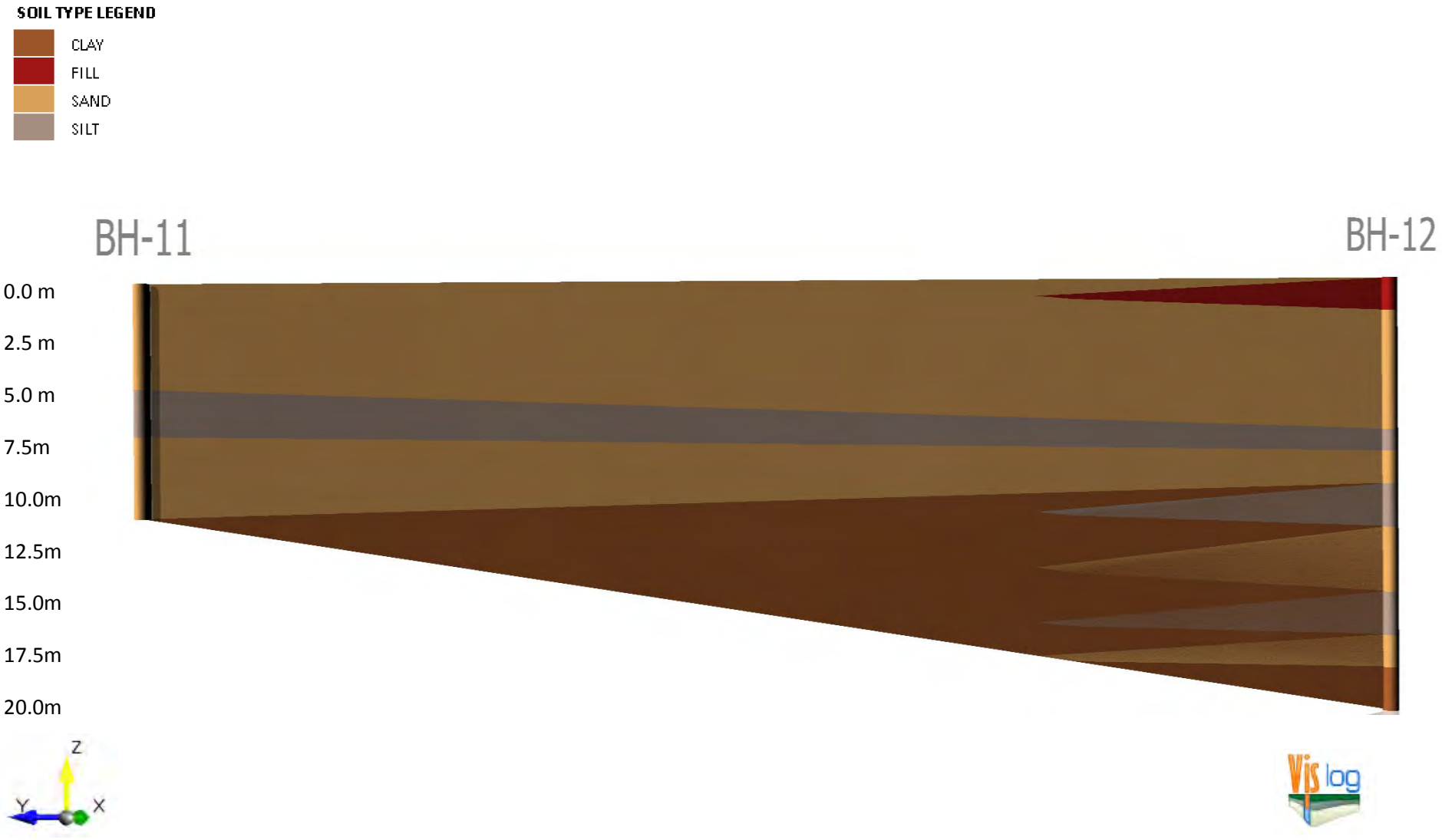
Soil Profile-02

Soil Profile-03

Soil Profile-04

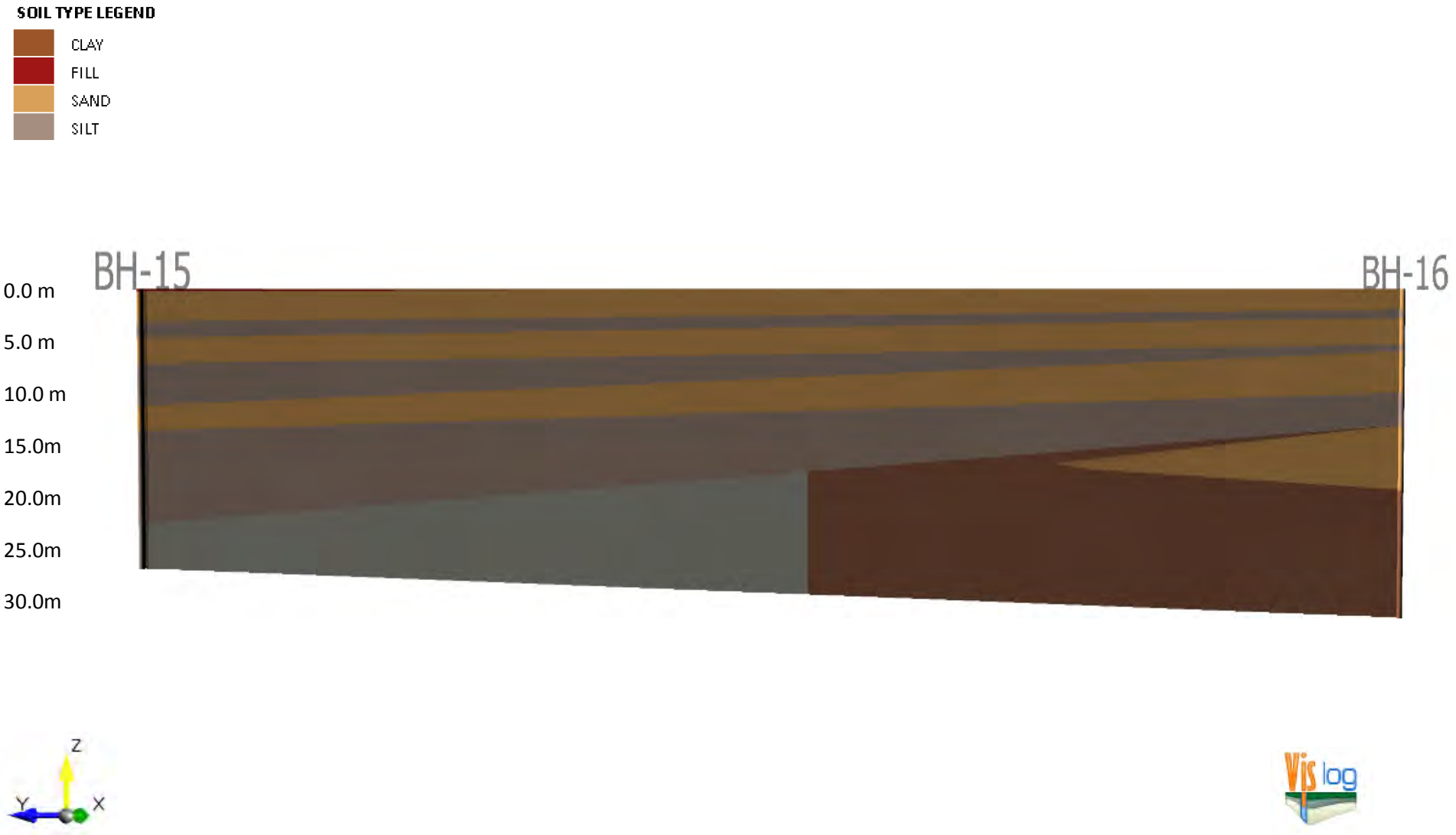


Soil Profile-05

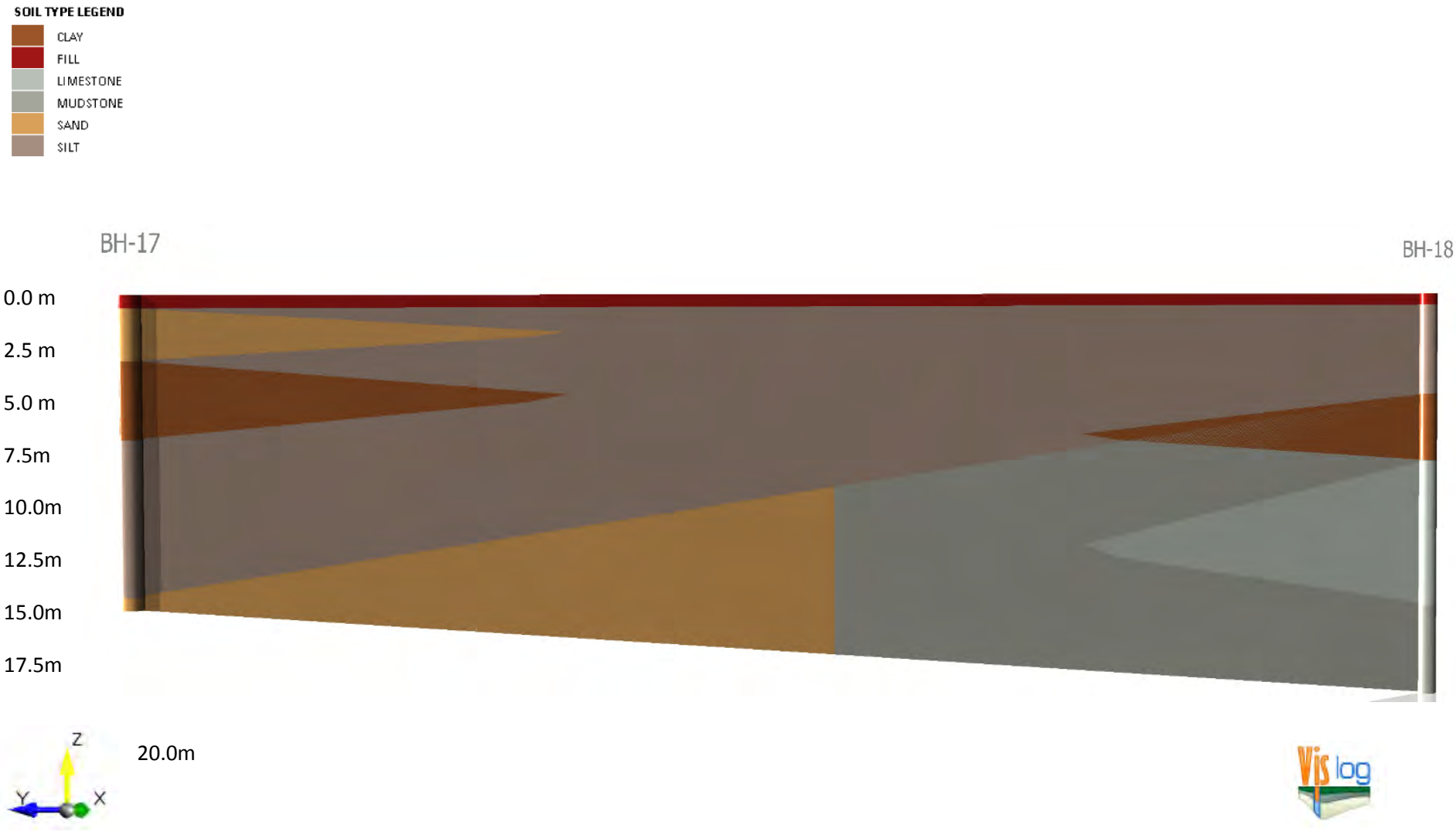


Soil Profile-06

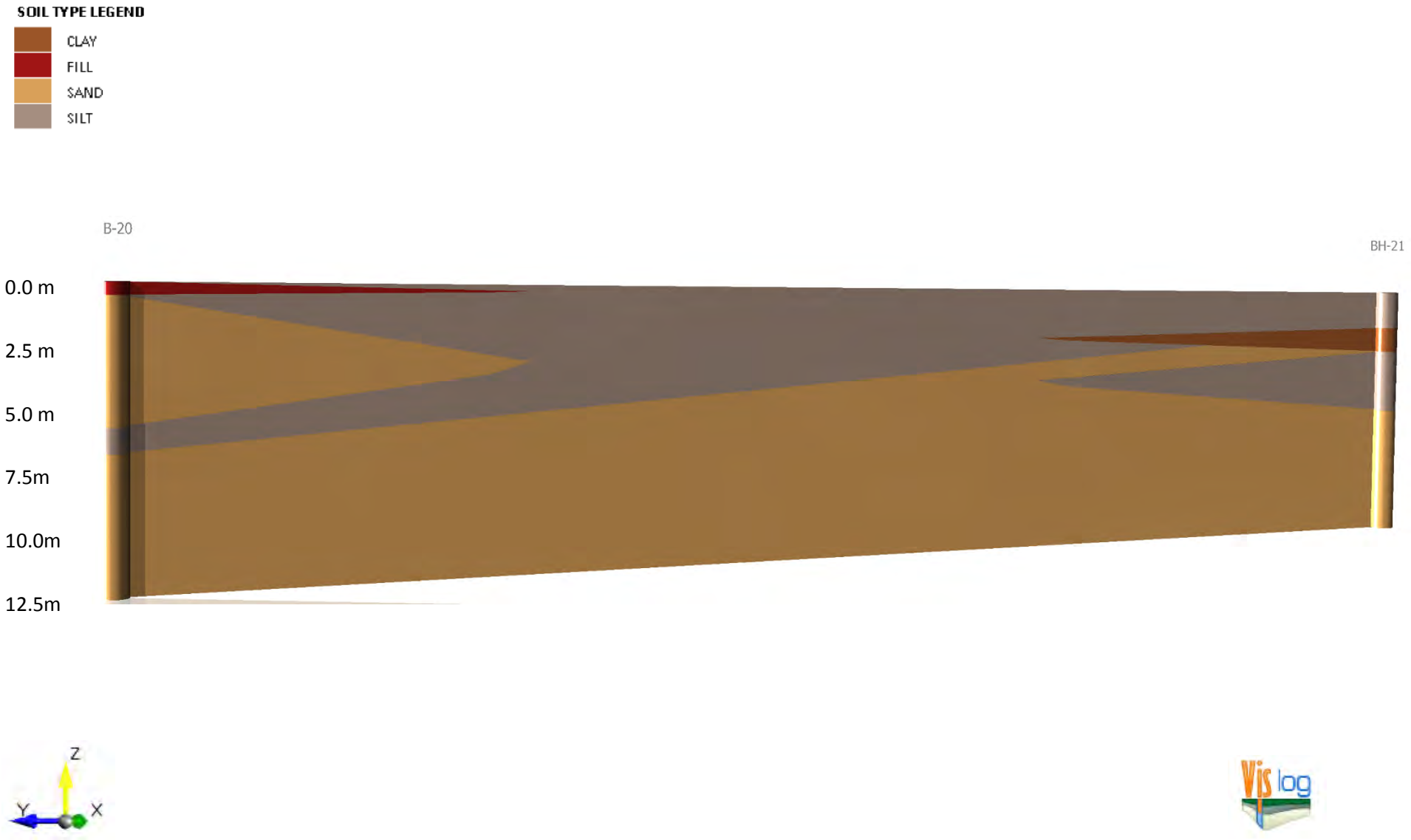
Soil Profile-07



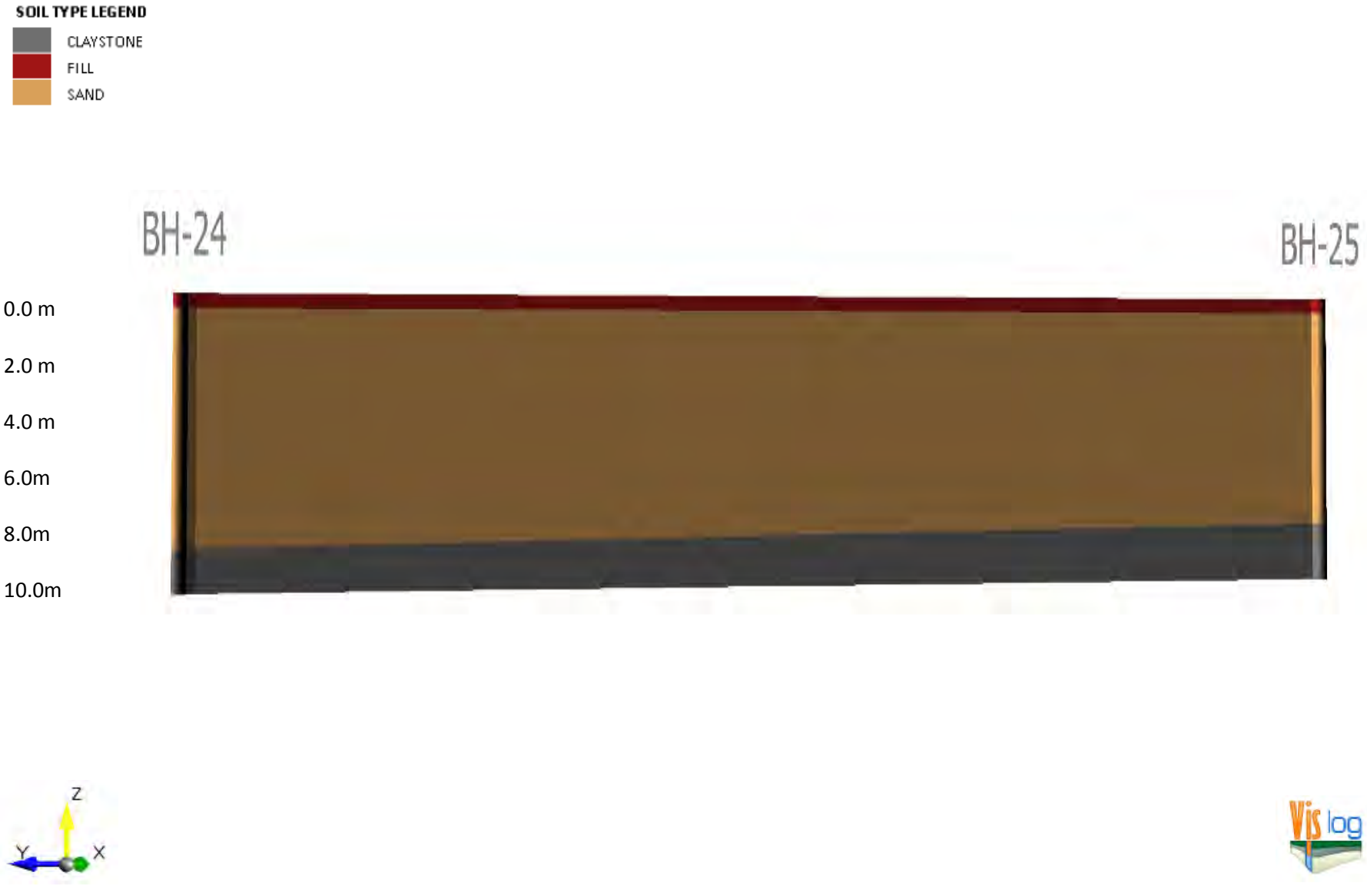
Soil Profile-08



Soil Profile-09



Soil Profile-10



Soil Profile-11

Appendix D

Laboratory Test Results

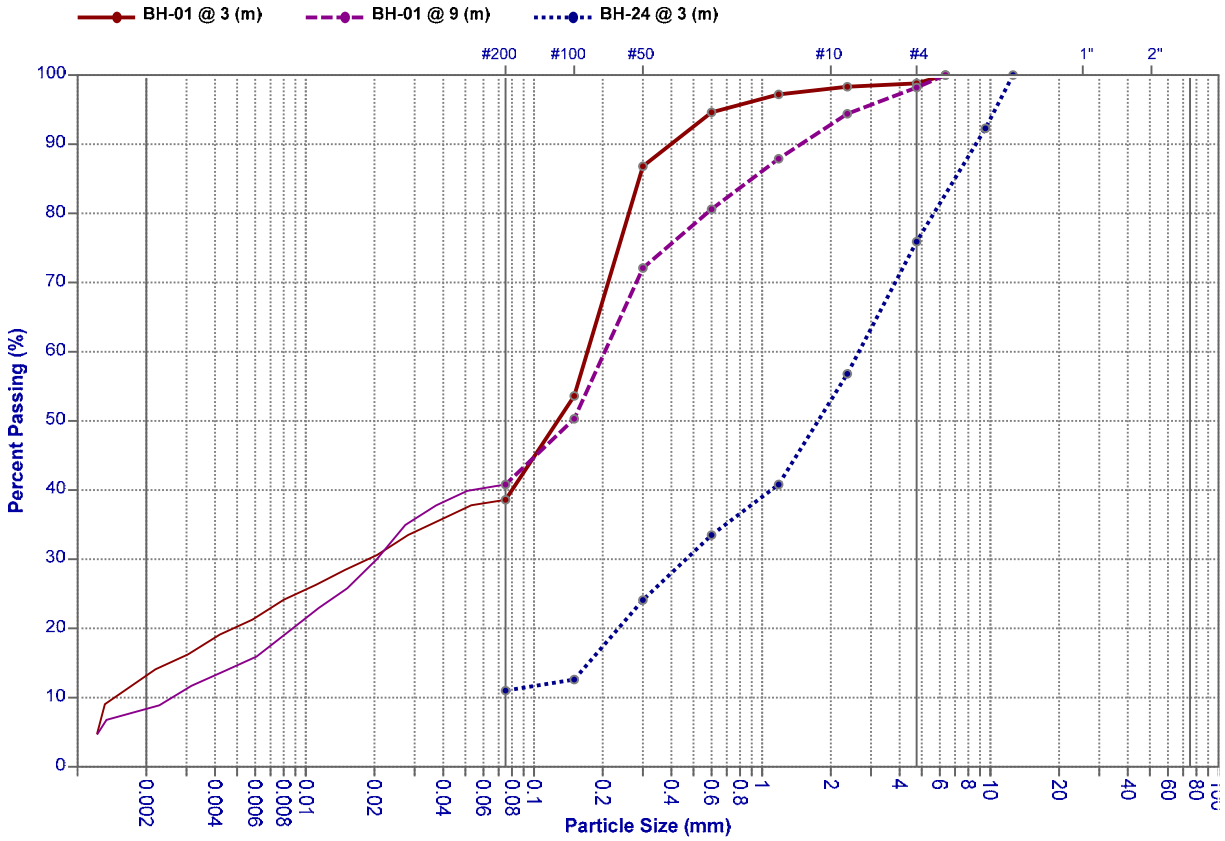
LTP-1

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
13.2	25.4	60.2	1.2	-
8.4	32.4	57.4	1.8	-
-	11	64.9	24.1	-

Classification

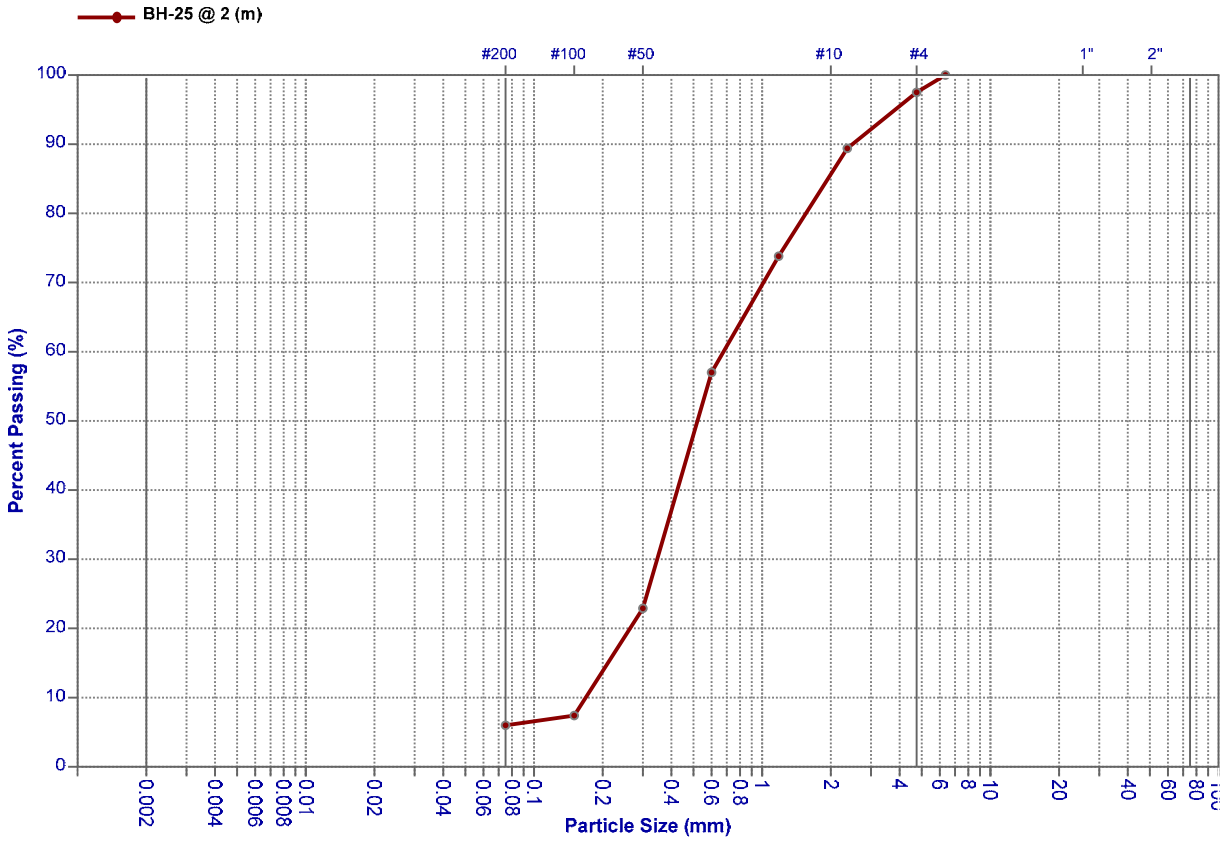
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-01	3	0.001	0.019	0.127	0.171	2.111	171	-	-	N/A	SM	A-4
BH-01	9	0.003	0.02	0.147	0.204	0.654	68	-	-	N/A	SM	A-4
BH-24	3	-	0.464	1.758	2.653	1.068	-	-	-	N/A	SW-SM	A-1-b

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	6	91.5	2.5	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-25	2	0.168	0.347	0.52	0.677	1.059	4.03	-	-	N/A	SP-SM	A-3

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-24	8.4	12.4	1.99	2.24
BH-25	8.24	11.24	2.05	2.28

Unconfined Compression Test

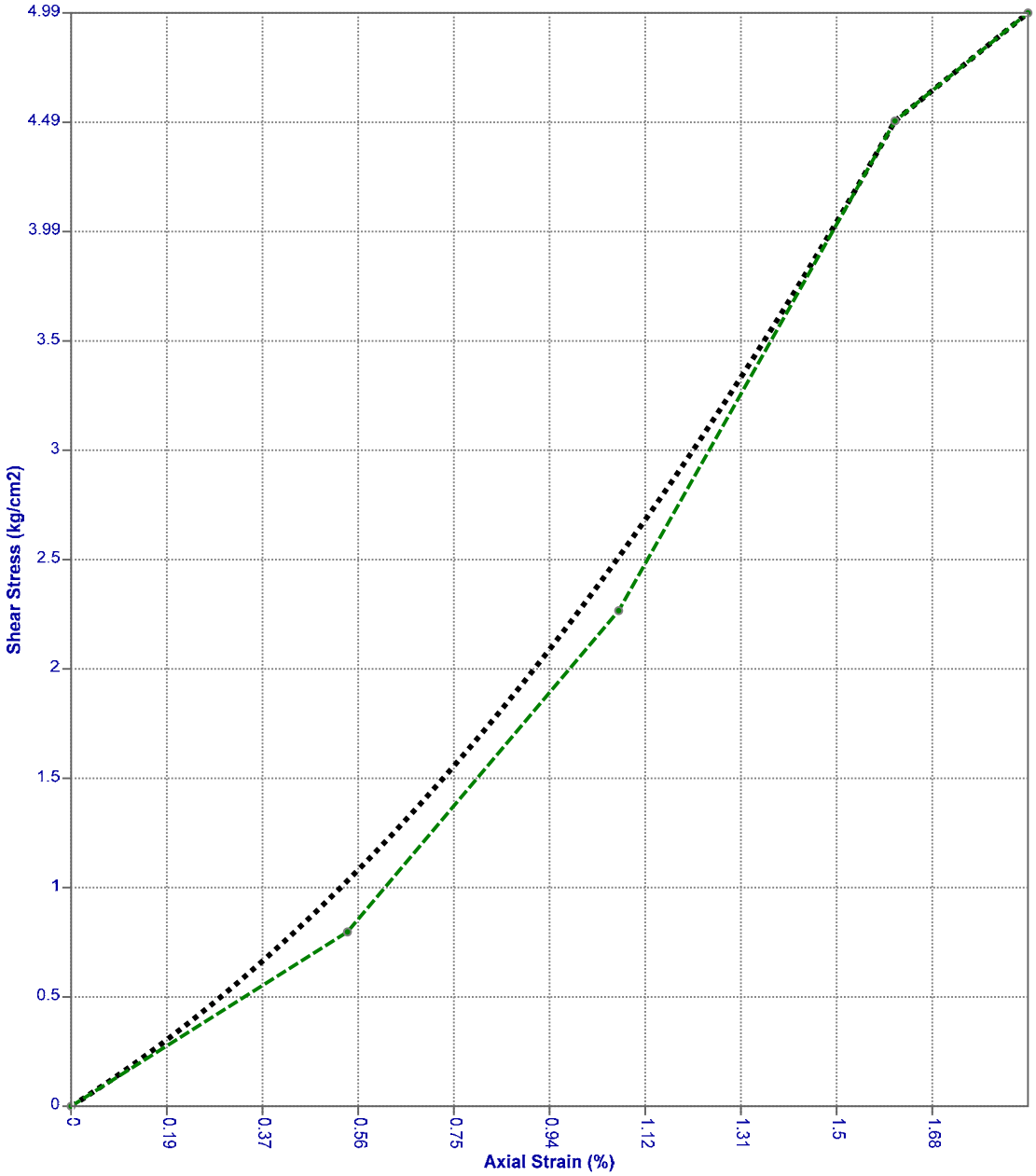
Project :	GI for Yellow BRTS Line	Borehole :	BH-24
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8.4 (m)
Job No.:	K19-1092-101	Rock Name :	Claystone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
4.719	9.337	2	Moist	12.4	1.99	4.99	2.5



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

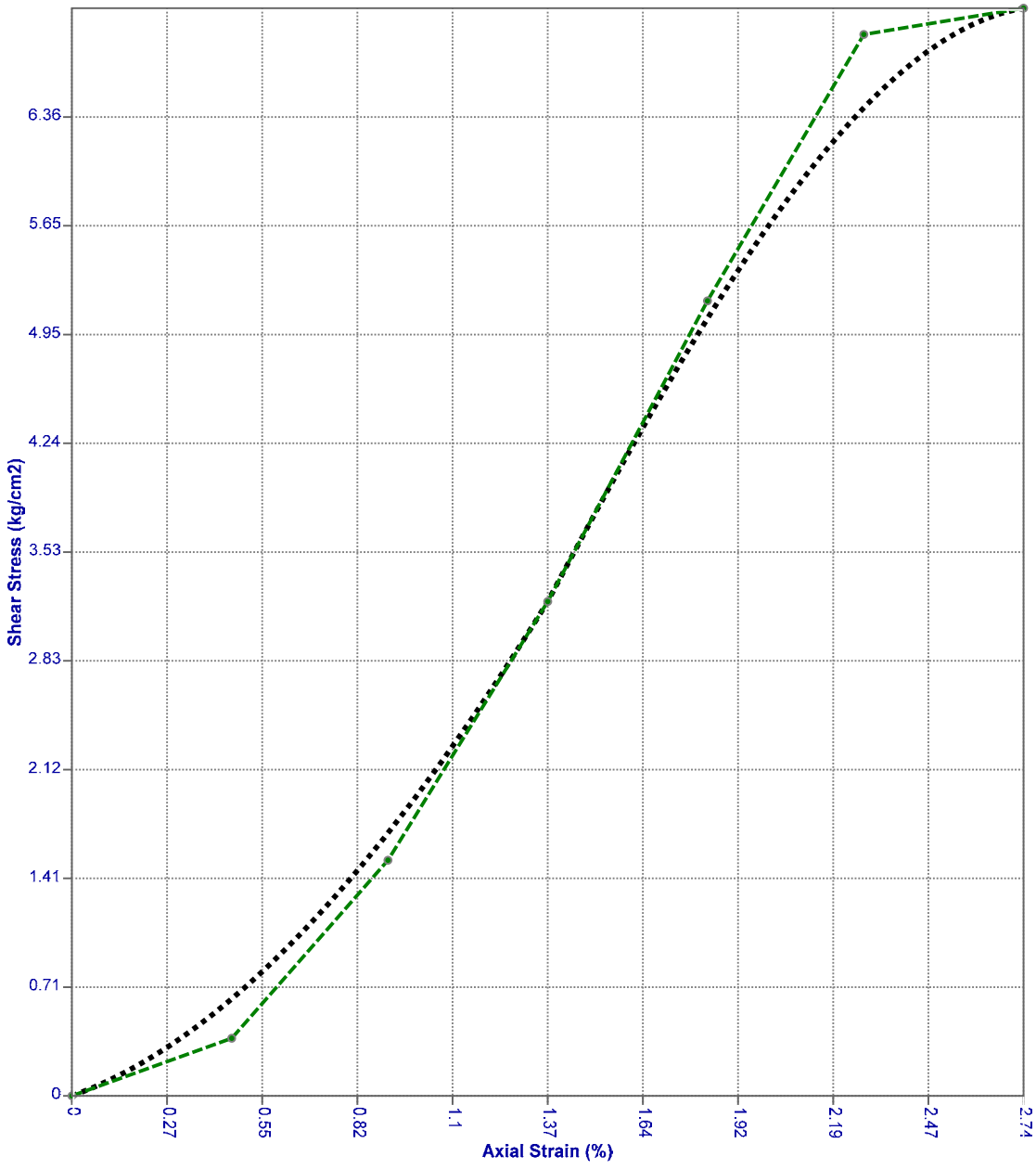
Project :	GI for Yellow BRTS Line	Borehole :	BH-25
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8.24 (m)
Job No.:	K19-1092-101	Rock Name :	Claystone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	10.943	2	Moist	11.24	2.05	7.07	3.54



Unified Description :
AASHTO Description :

Tested By :

Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C-1580, D-1411
D-4972

Borehole	Sample Depth (m)	Description	Value
BH-24	3	Sulphate Content (%)	0.01
BH-24	3	Chloride Content (%)	0.11
BH-24	3	Organic Matter (%)	0.91

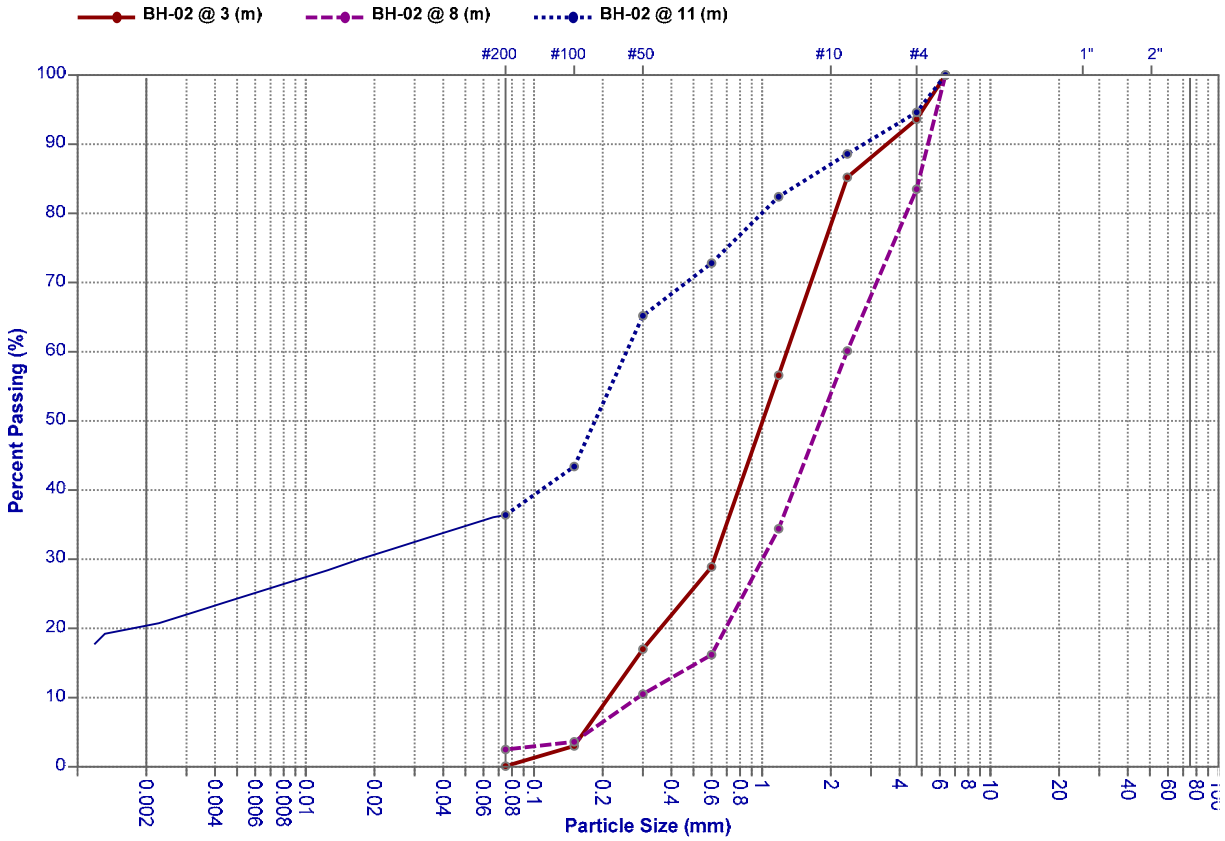
LTP-2

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	0.1	93.5	6.4	-
-	2.5	81	16.5	-
20.4	16	58.2	5.4	-

Classification

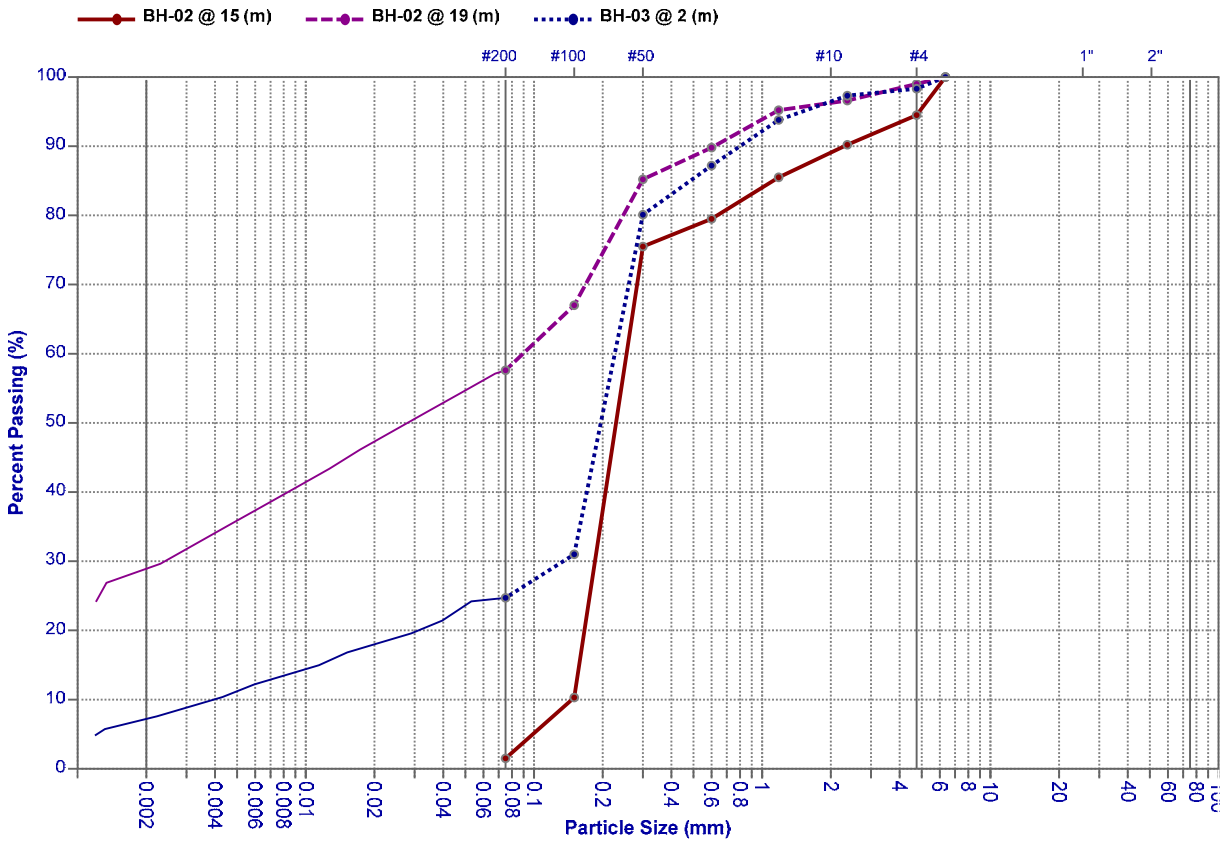
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-02	3	0.212	0.616	1.004	1.281	1.397	6.042	-	-	N/A	SW	A-2-4
BH-02	8	0.285	1.002	1.797	2.354	1.497	8.26	-	-	N/A	SW	A-2-4
BH-02	11	0.001	0.017	0.185	0.254	1.138	254	29.7	8.3	N/A	SC	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	1.5	93	5.5	-
28.9	28.7	41.4	1	-
7.2	17.5	73.6	1.7	-

Classification

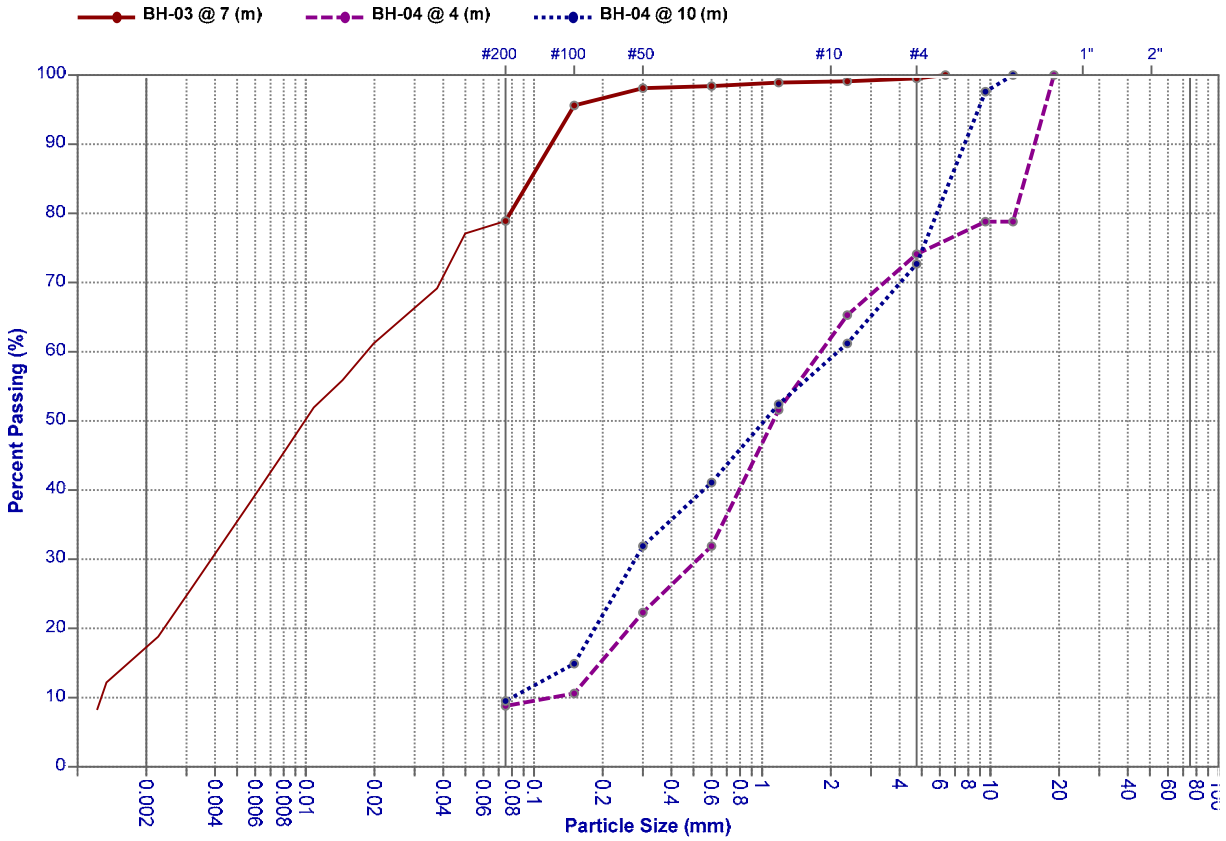
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-02	15	0.146	0.185	0.229	0.254	0.923	1.74	-	-	N/A	SP	A-2-4
BH-02	19	0.001	0.002	0.028	0.09	0.044	90	29.3	3.3	N/A	ML	A-4
BH-03	2	0.004	0.134	0.196	0.226	19.863	56.5	-	-	N/A	SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
17.3	61.6	20.6	0.5	-
-	8.8	65.3	25.9	-
-	9.5	63.2	27.3	-

Classification

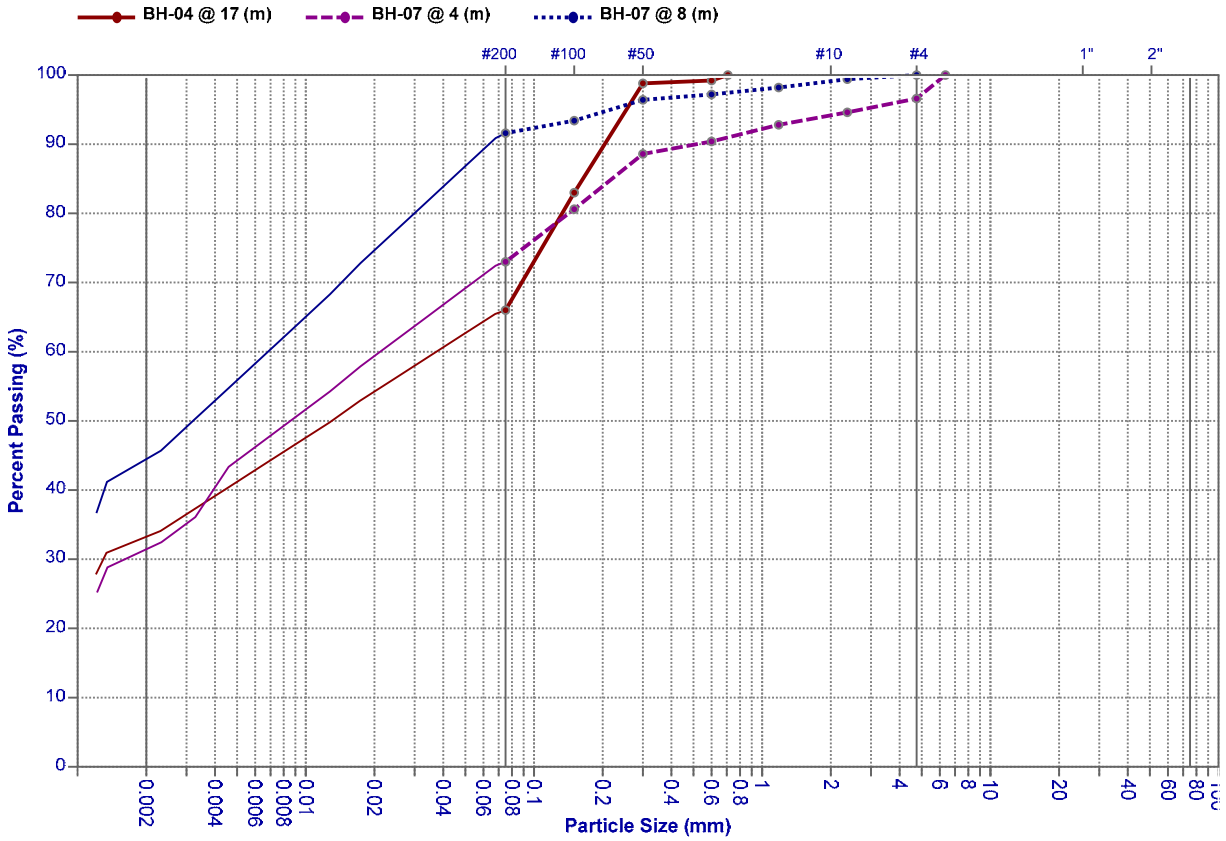
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-03	7	0.001	0.004	0.01	0.018	0.889	18	-	-	N/A	ML	A-4
BH-04	4	0.119	0.523	1.117	1.805	1.273	15.168	-	-	N/A	SW-SM	A-2-4
BH-04	10	0.08	0.278	1.022	2.147	0.45	26.838	-	-	N/A	SP-SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
33.3	32.7	34	-	-
31.4	41.6	23.6	3.4	-
44.5	47.1	8.4	-	-

Classification

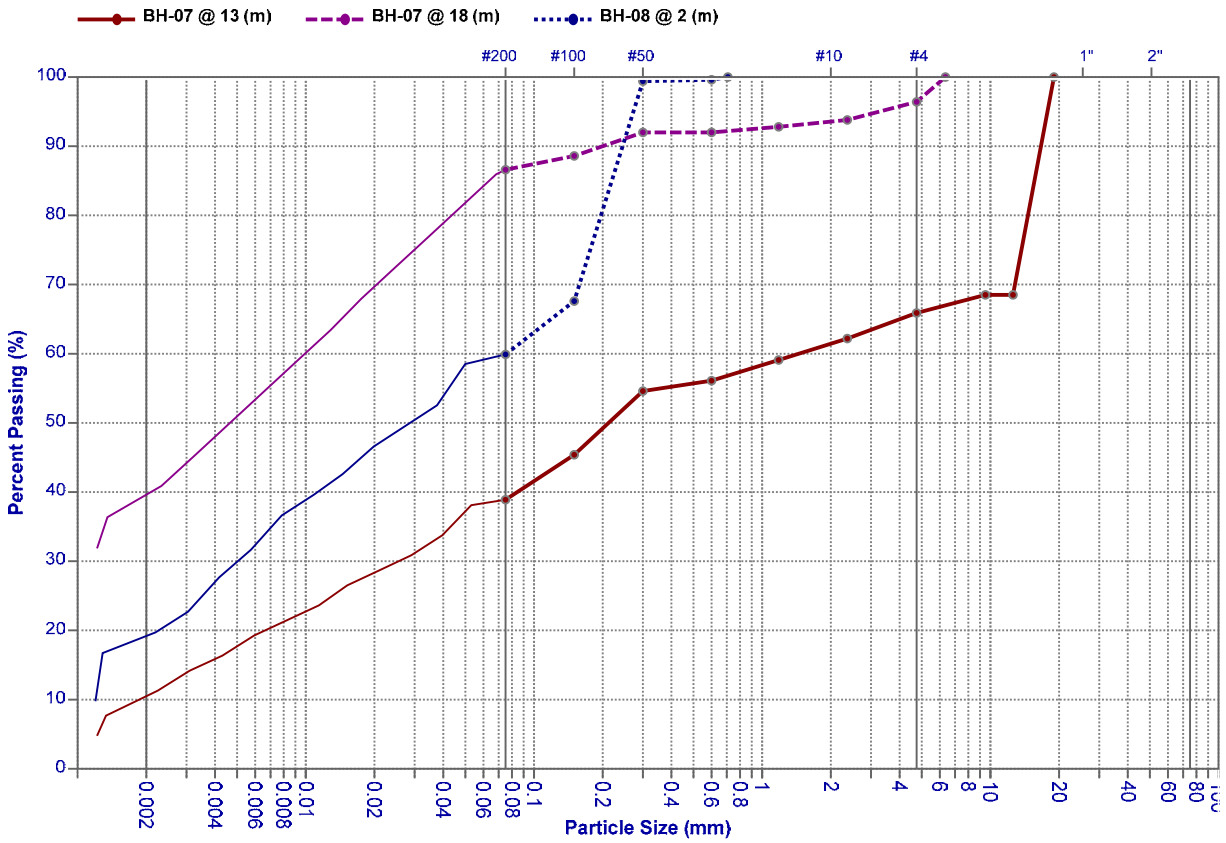
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-04	17	0.001	0.001	0.013	0.037	0.027	37	21.3	4.2	N/A	CL-ML	A-4
BH-07	4	0.001	0.002	0.009	0.021	0.19	21	18.1	2.1	N/A	ML	A-4
BH-07	8	0.001	0.001	0.003	0.007	0.143	7	41.5	9.9	N/A	ML	A-7-5

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
10.5	28.4	27	34.1	-
39.6	47	9.8	3.6	-
19.2	40.7	40.1	-	-

Classification

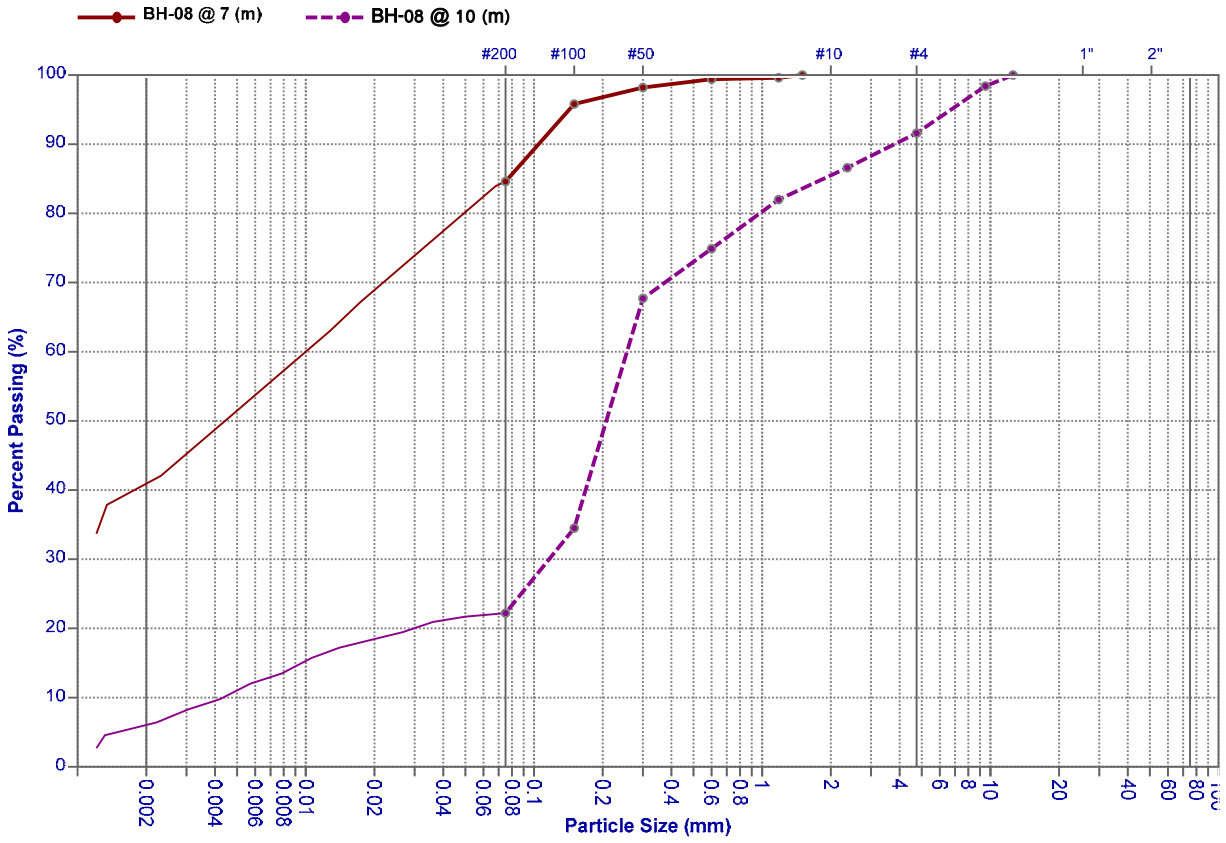
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-07	13	0.002	0.026	0.212	1.443	0.234	721.5	-	-	N/A	GM	A-4
BH-07	18	0.001	0.001	0.005	0.01	0.1	10	37.1	7	N/A	ML	A-4
BH-08	2	0.001	0.005	0.029	0.076	0.329	76	-	-	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
40.9	43.7	15.4	-	-
6	16.2	69.4	8.4	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-08	7	0.001	0.001	0.004	0.01	0.1	10	36.3	4.1	N/A	ML	A-4
BH-08	10	0.004	0.116	0.207	0.255	13.192	63.75	-	-	N/A	SM	A-2-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-02
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	11 (m)
Job No.:	K19-1092-101	Classification :	SC
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

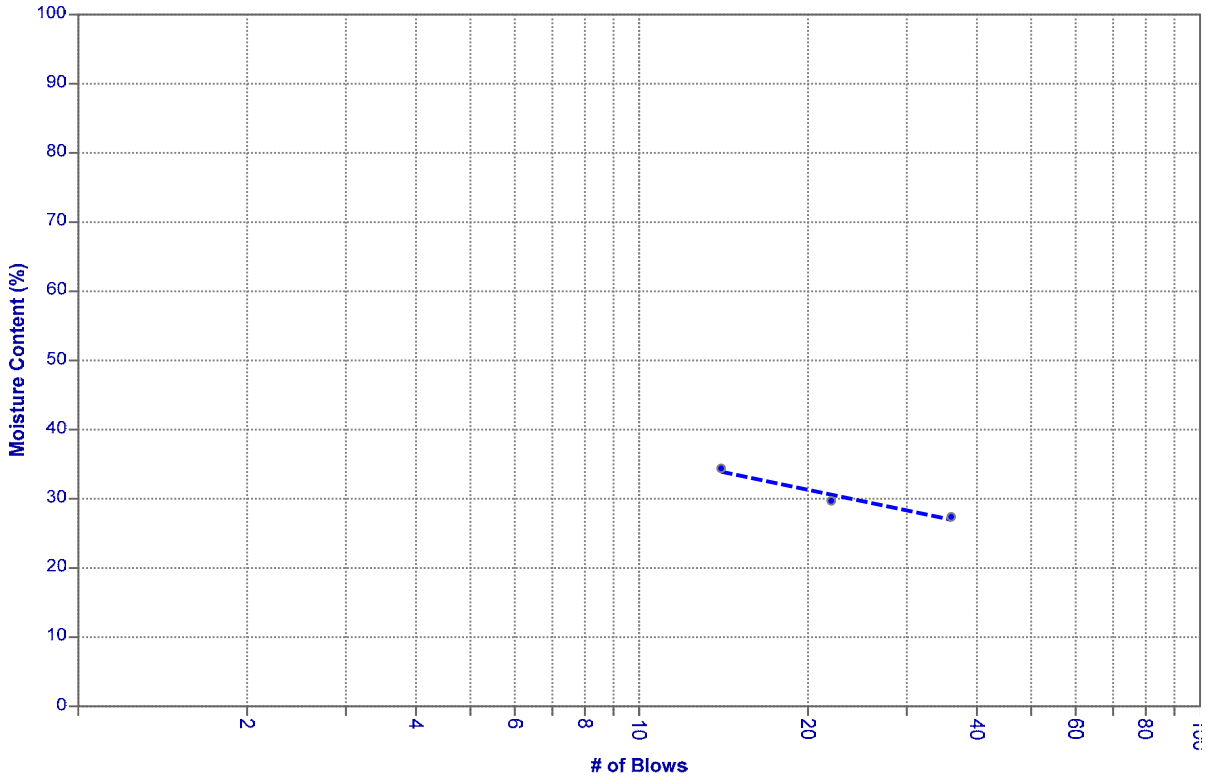
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.7	23.5	19.2	14	34.4
6.6	22.7	19.01	22	29.7
6.7	21.5	18.32	36	27.4
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	17.1	15.3	21.4

LL = 29.7 % **PL = 21.4 %** **PI=8.3**



Unified Description : Clayey Sand With Gravel
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-02
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	19 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

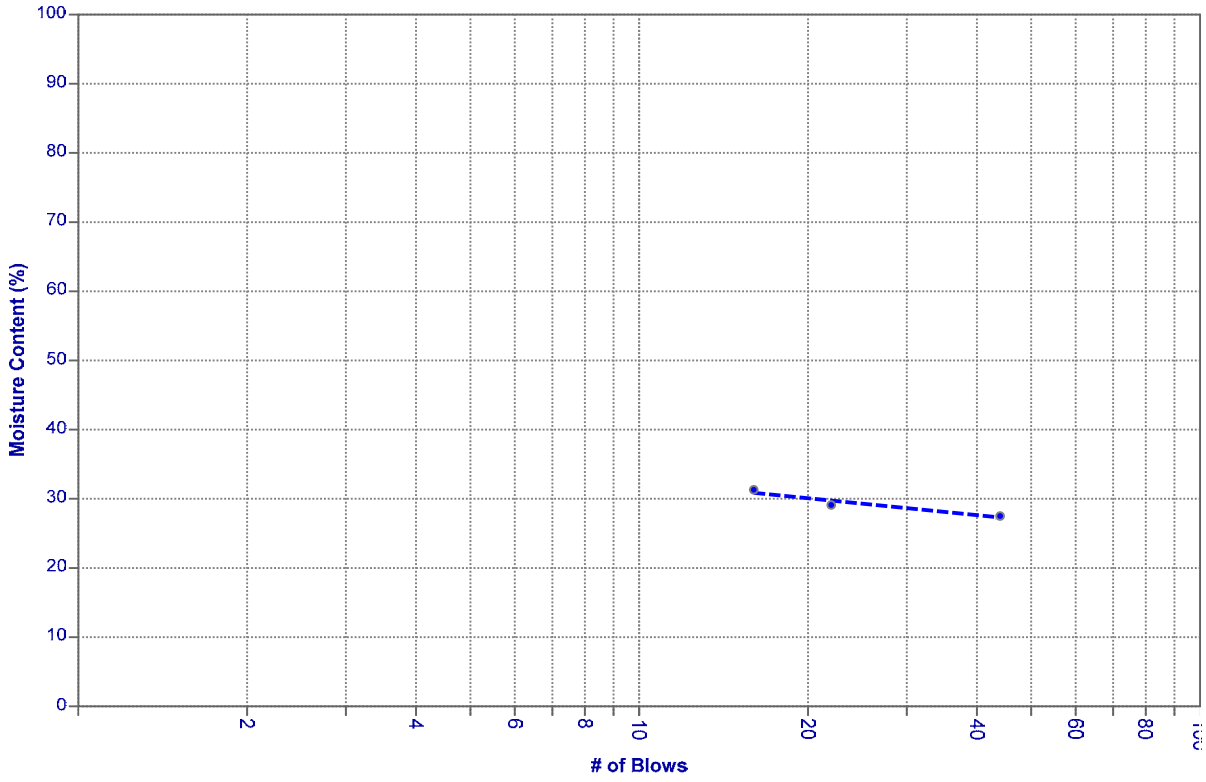
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.8	26.1	21.5	16	31.3
6.9	26	21.7	22	29.1
6.7	22	18.7	44	27.5
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	17.4	15.21	26

LL = 29.3 % **PL = 26 %** **PI=3.3**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-04
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	17 (m)
Job No.:	K19-1092-101	Classification :	CL-ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

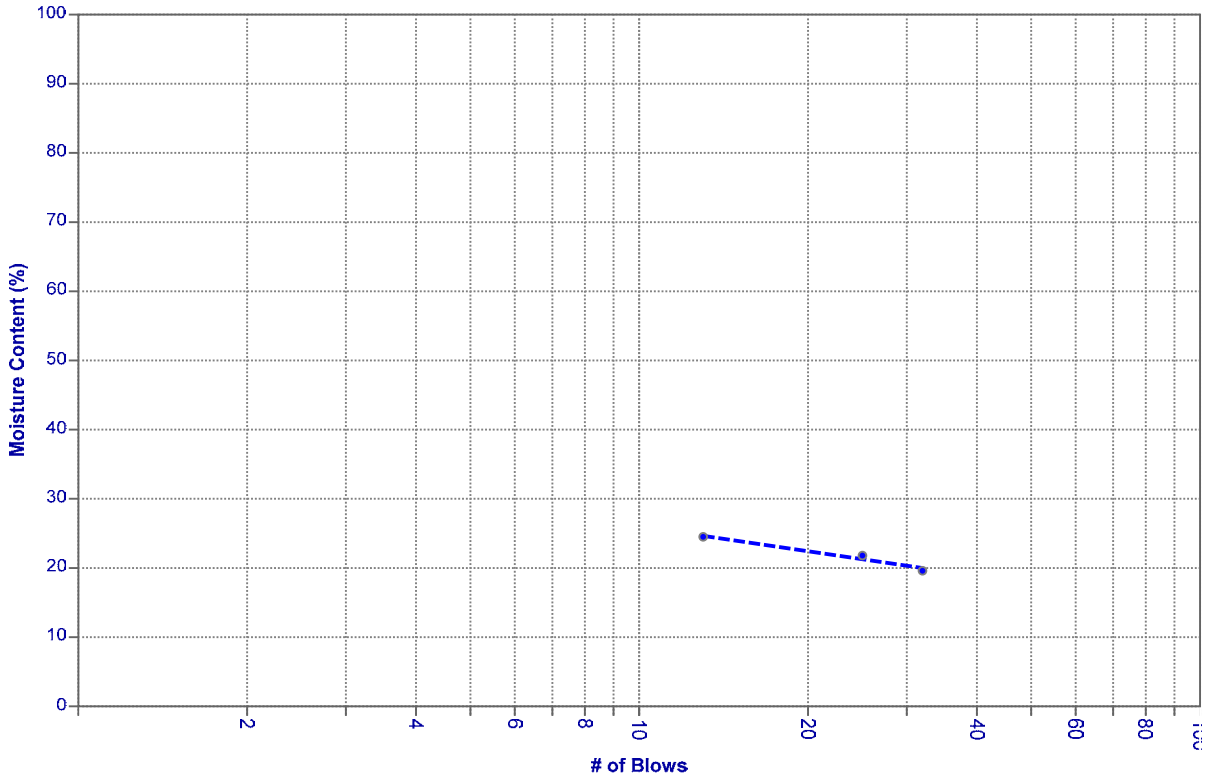
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7.1	24.4	21	13	24.5
6.6	26.7	23.1	25	21.8
6.6	26.7	23.4	32	19.6
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7	19.3	17.5	17.1

LL = 21.3 % **PL = 17.1 %** **PI=4.2**



Unified Description : Silty Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-07
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

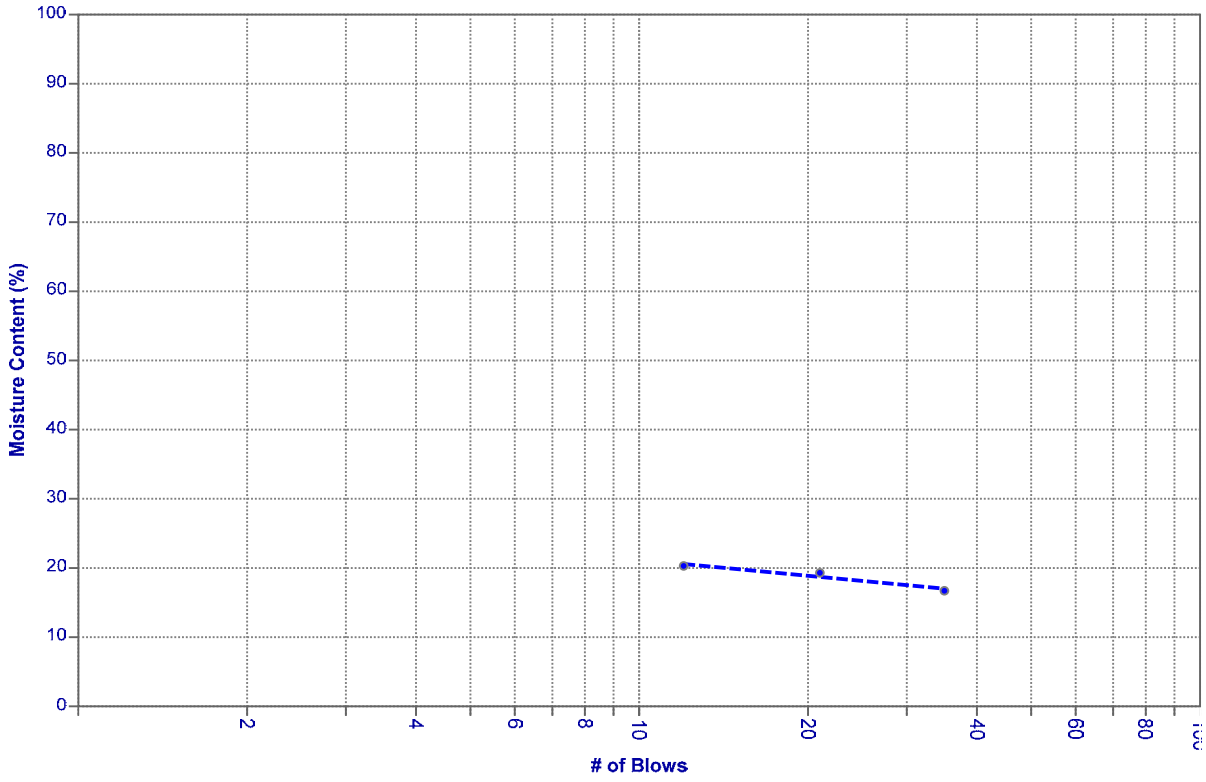
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	30	26.1	12	20.3
7	24.9	22	21	19.3
6.7	27	24.1	35	16.7
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7	18.6	17	16

LL = 18.1 % **PL = 16 %** **PI=2.1**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-07
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

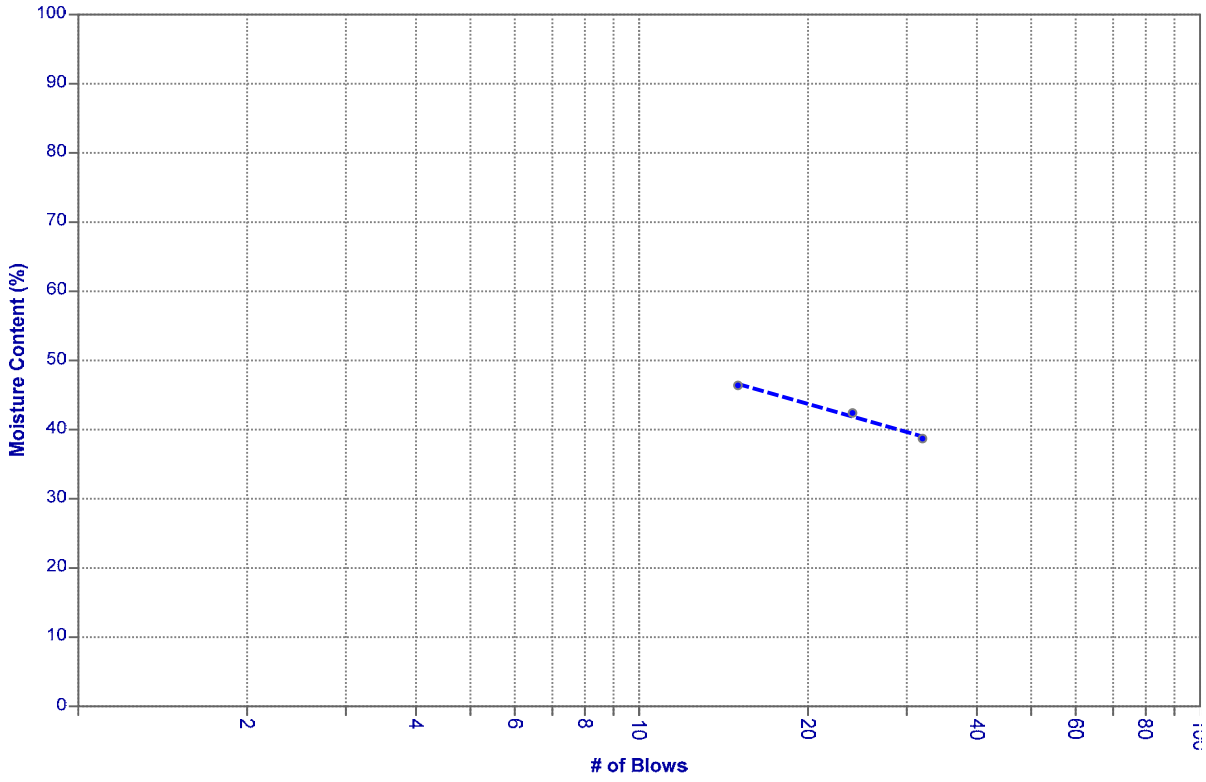
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7	19.3	15.4	15	46.4
7	19.1	15.5	24	42.4
6.9	19.8	16.2	32	38.7
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	16.8	14.4	31.6

LL = 41.5 % **PL = 31.6 %** **PI=9.9**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-07
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	18 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

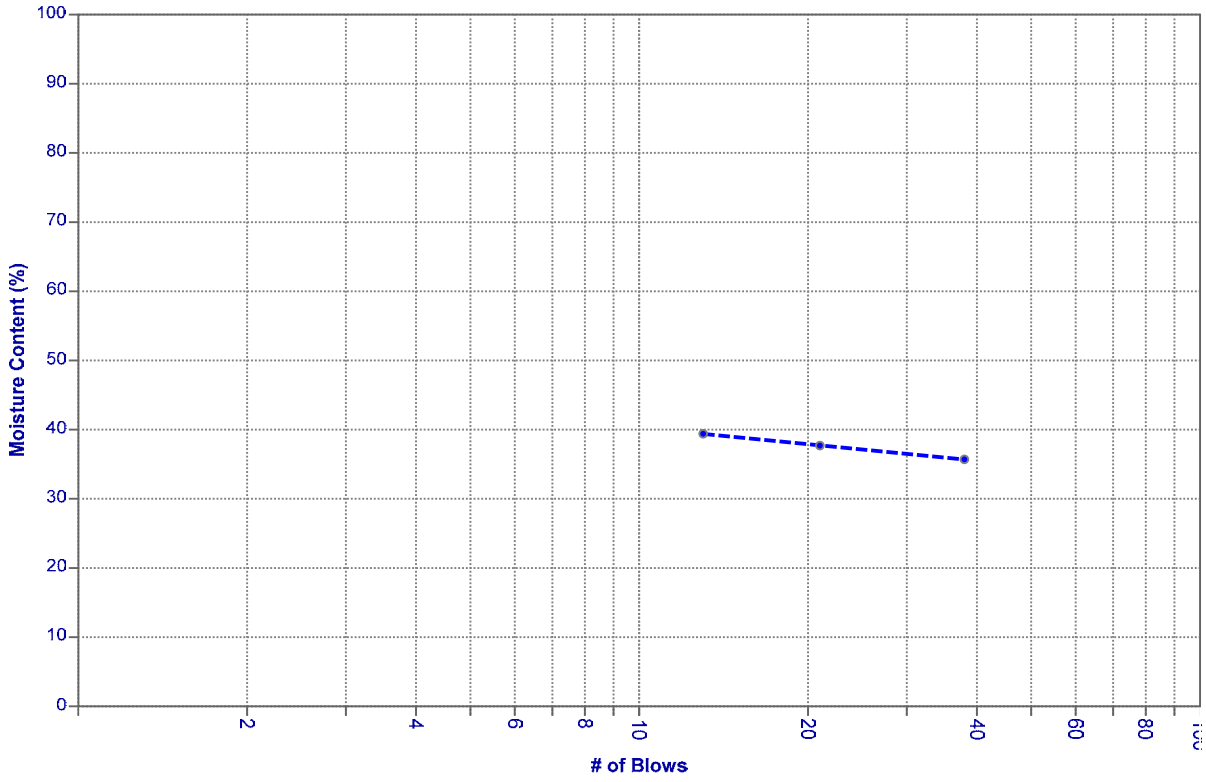
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7	21.5	17.4	13	39.4
7.1	22.8	18.5	21	37.7
6.6	21.8	17.8	38	35.7
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	19	16.2	30.1

LL = 37.1 % **PL = 30.1 %** **PI=7**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-08
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	7 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-4318

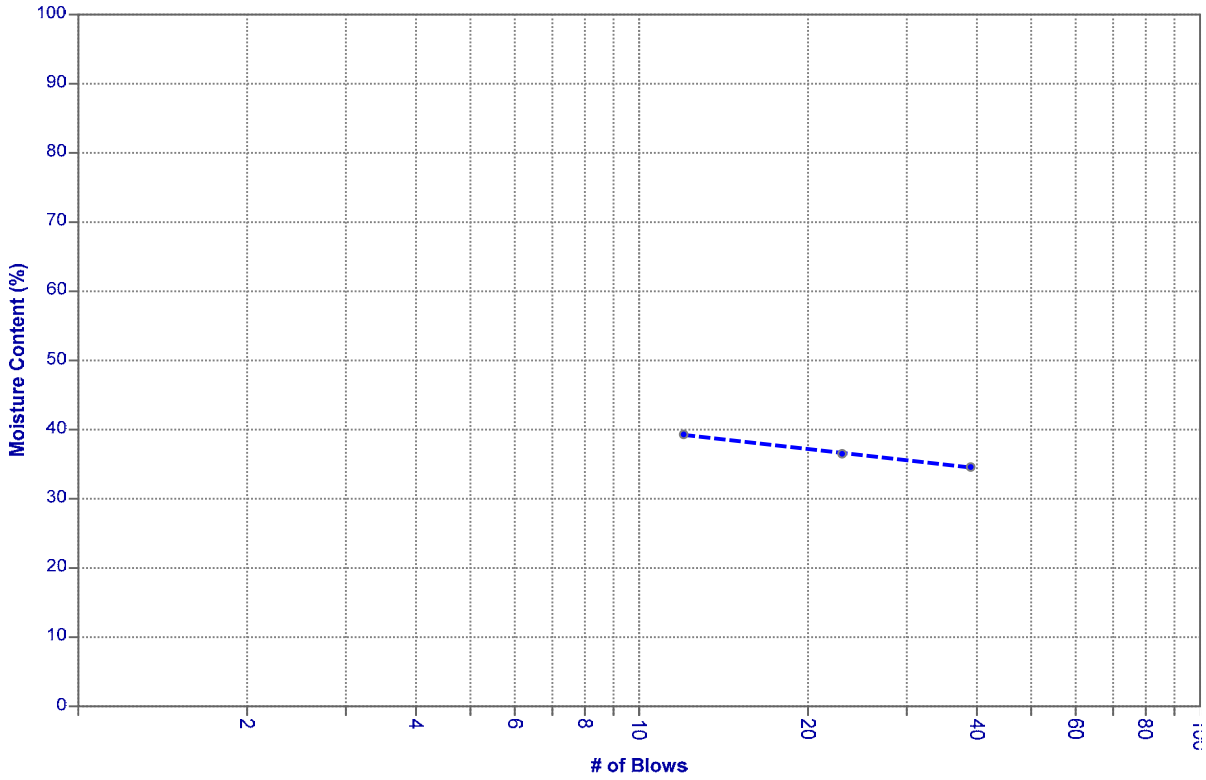
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.5	22.1	17.7	12	39.3
6.6	18.2	15.1	23	36.5
7	17.5	14.8	39	34.6
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	18.3	15.5	32.2

LL = 36.3 % **PL = 32.2 %** **PI=4.1**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

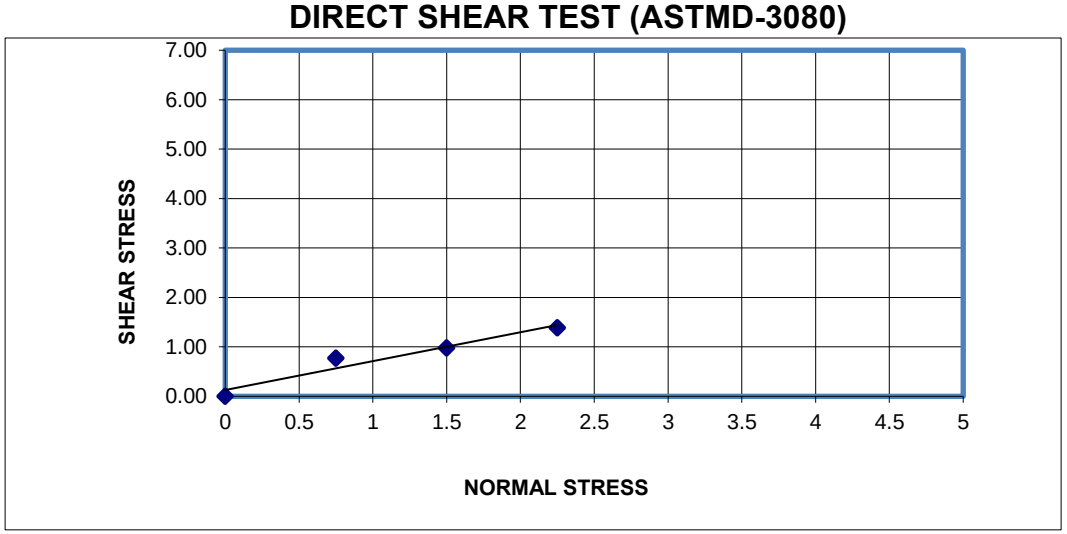
SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-02	8	4.05	1.88	1.96
BH-03	7	6.4	1.89	2.02
BH-04	10	5.57	1.92	2.03
BH-07	13	9.31	1.98	2.16
BH-08	7	27.54	1.5	1.91

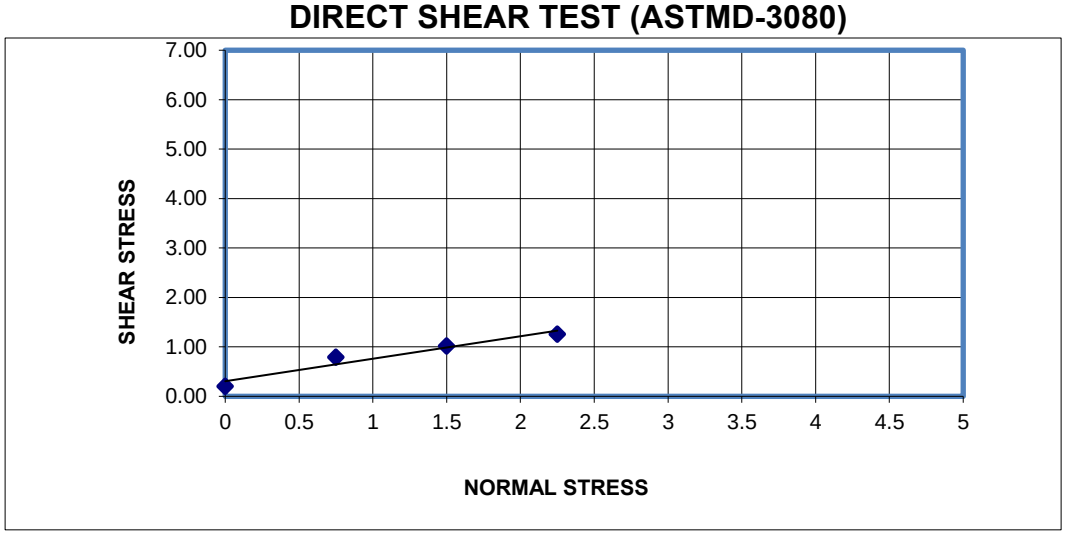
Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-02**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**8.0 - 8.90**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.75	0.77
1.50	0.98
2.25	1.39
Cohesion (c)	0.00
Angle of friction (Φ)	31.71



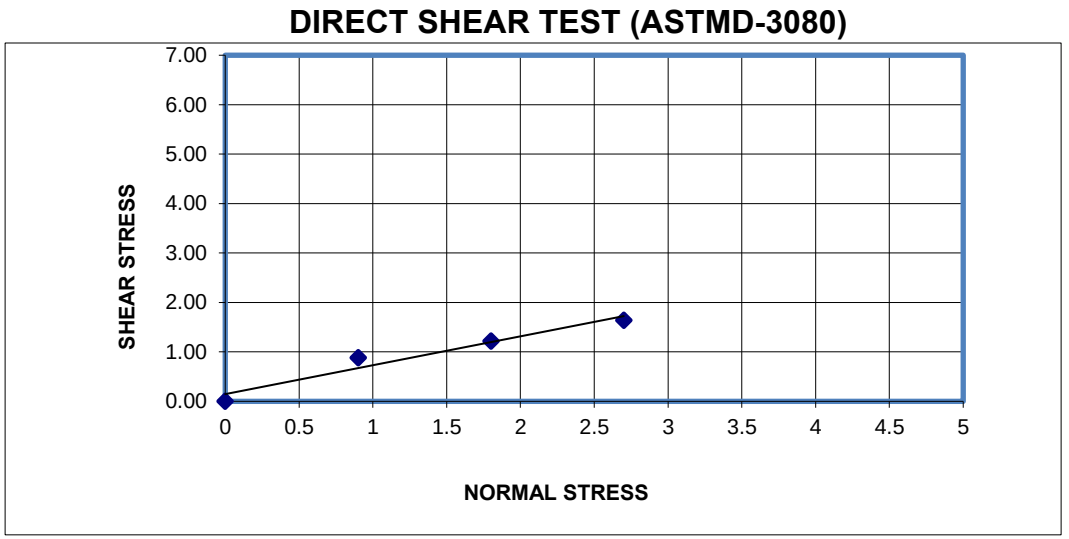
Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-03**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**7.0 - 7.90**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.20
0.75	0.79
1.50	1.02
2.25	1.26
Cohesion (c)	0.20
Angle of friction (Φ)	25.23



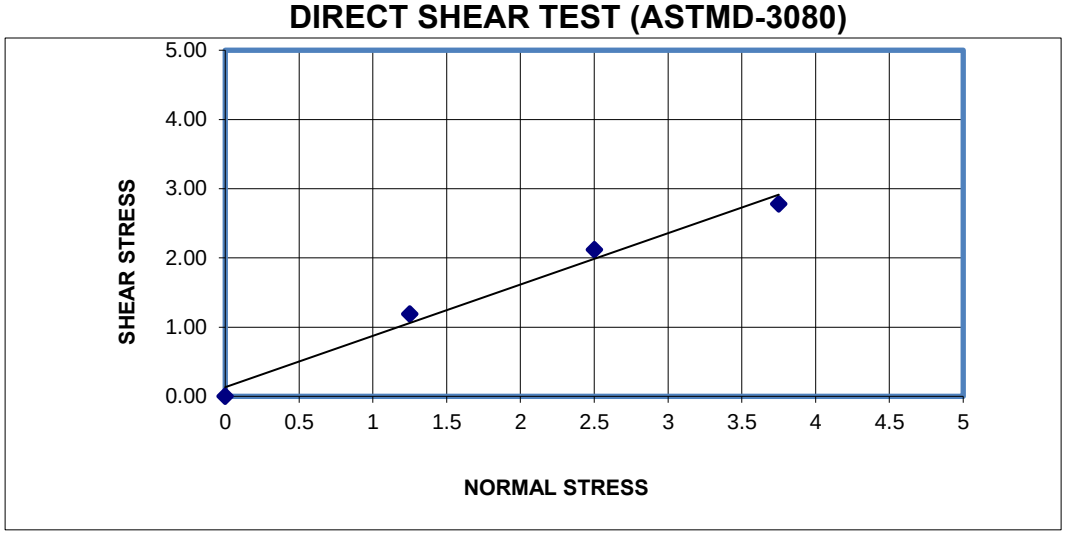
Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-04**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**10.0 - 10.80**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.90	0.88
1.80	1.22
2.70	1.64
Cohesion (c)	0.00
Angle of friction (Φ)	31.28



Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-07**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**13.0 - 13.80 (m)**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS-1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
1.25	1.19
2.50	2.12
3.75	2.78
Cohesion (c)	0.00
Angle of friction (Φ)	36.55



Unconfined Compression Test

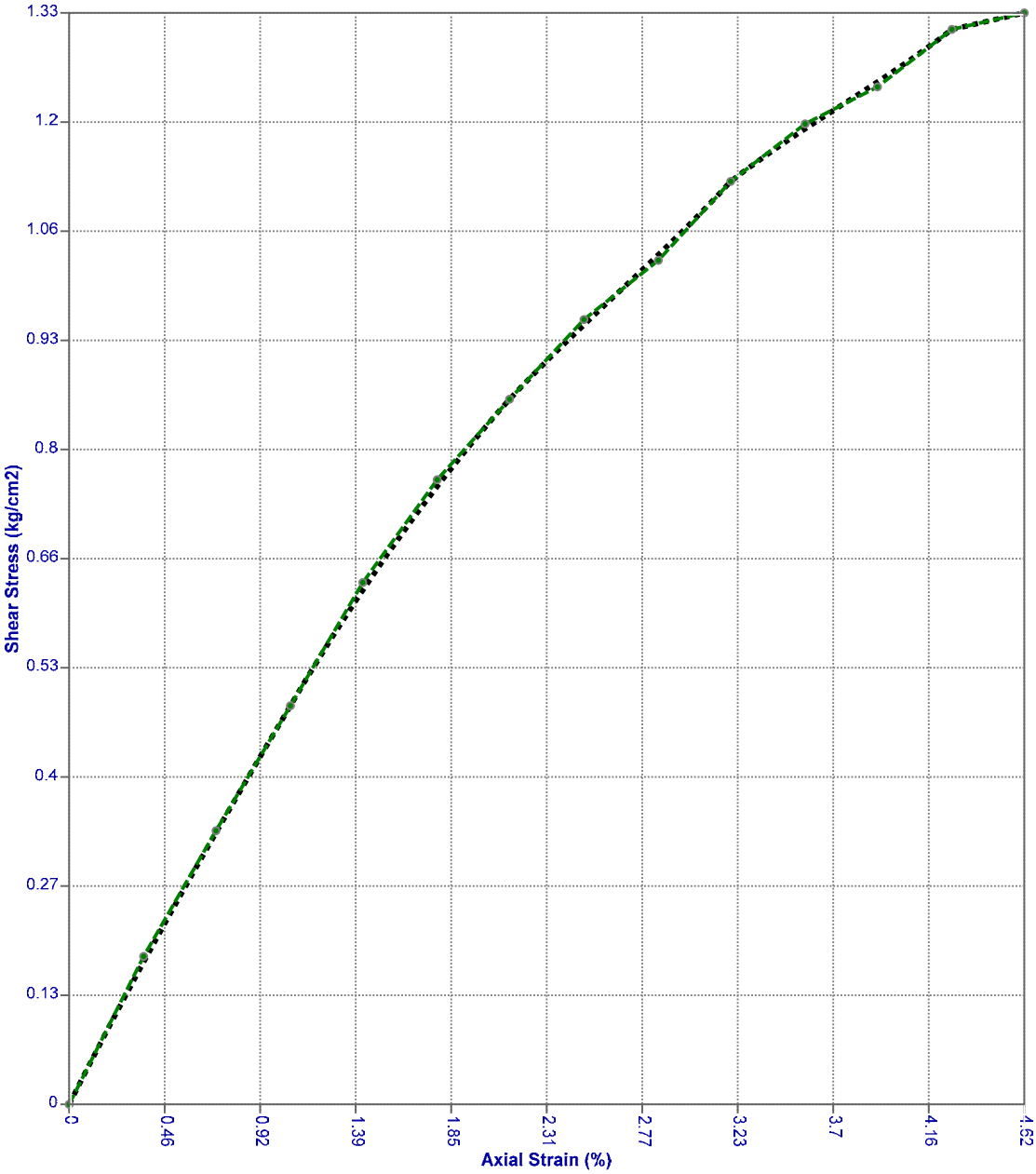
Project :	GI for Yellow BRTS Line	Borehole :	BH-08
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	7 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
7.028	14.055	2	Moist	27.54	1.5	1.33	0.66



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

1D Consolidation Test

Project :	GI for Yellow BRTS Line	Borehole :	BH-08
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	7.0 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

Soil Testing Services

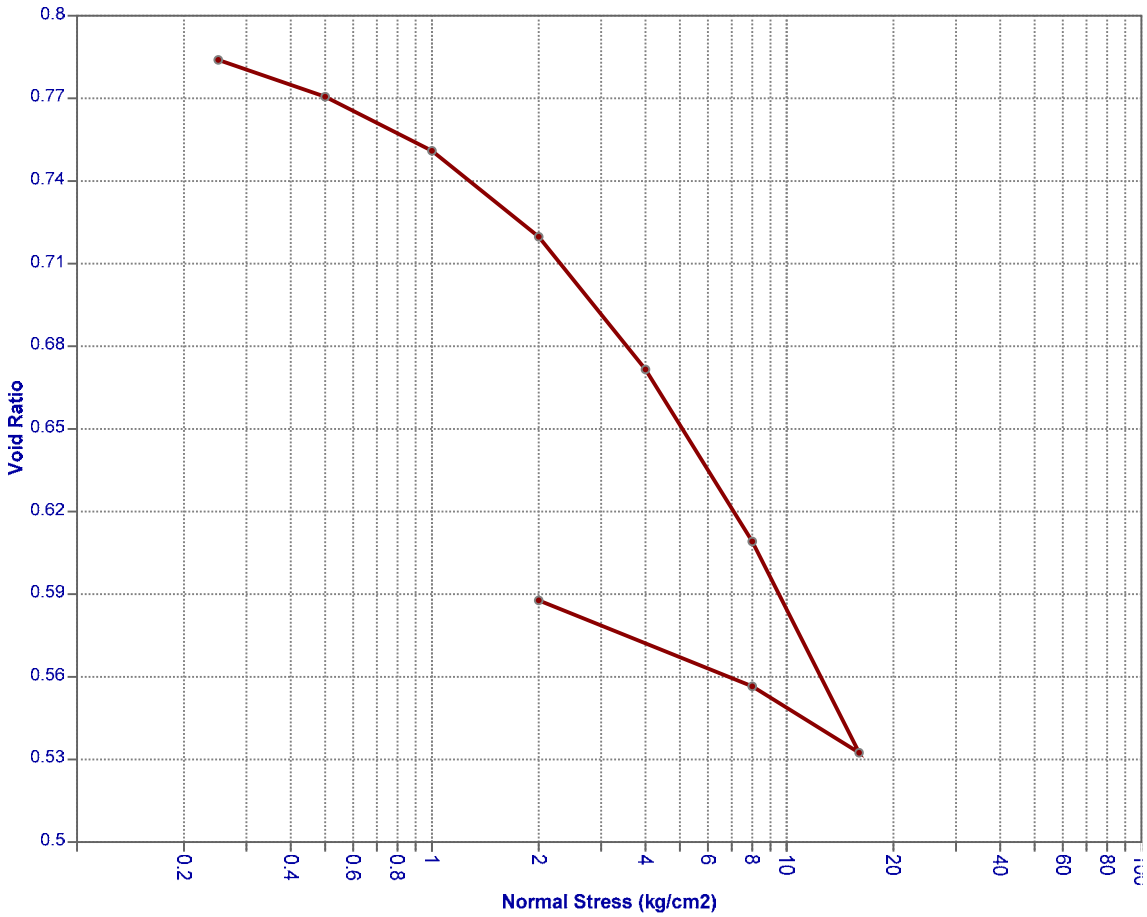
ASTM D2435

Sample Info

Diameter (cm)	Height (cm)	Dry Weight (gr)	Wet Weight Before (gr)	Wet Weight After (gr)	Void Ratio	Gs
6	2	84	111	112	0.78	2.65

Compression Parameters

Cc	Cs	Pre-Consolidation Pressure (kg/cm2)
0.27	0.06	4



Mv Values

P1 (kg/cm2)	P2 (kg/cm2)	e1	e2	Mv 1/ (kg/cm2)
0.25	0.5	0.784	0.771	3.00E-002
0.5	1	0.771	0.751	2.22E-002
1	2	0.751	0.72	1.78E-002
2	4	0.72	0.672	1.40E-002
4	8	0.672	0.609	9.34E-003
8	16	0.609	0.532	5.96E-003

Unified Description : Poorly Graded Sand With Gravel
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C-1580, D-1411
D-4972

Borehole	Sample Depth (m)	Description	Value
BH-03	2	Sulphate Content (%)	0.01
BH-08	7		0.02
BH-03	2	Chloride Content (%)	0.22
BH-08	7		0.28
BH-03	2	Organic Matter (%)	1.8
BH-08	7		3.32

Water Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

Soil Testing Services

ASTM D-5907, D-512, D-516, D-1293

Borehole	Sample	Sample Depth (m)	Total Salt Content (ppm)	Chloride Content (ppm)	Sulphate (ppm)	pH Values
BH-04	WS-1	11.50	1040	560	159	8.74

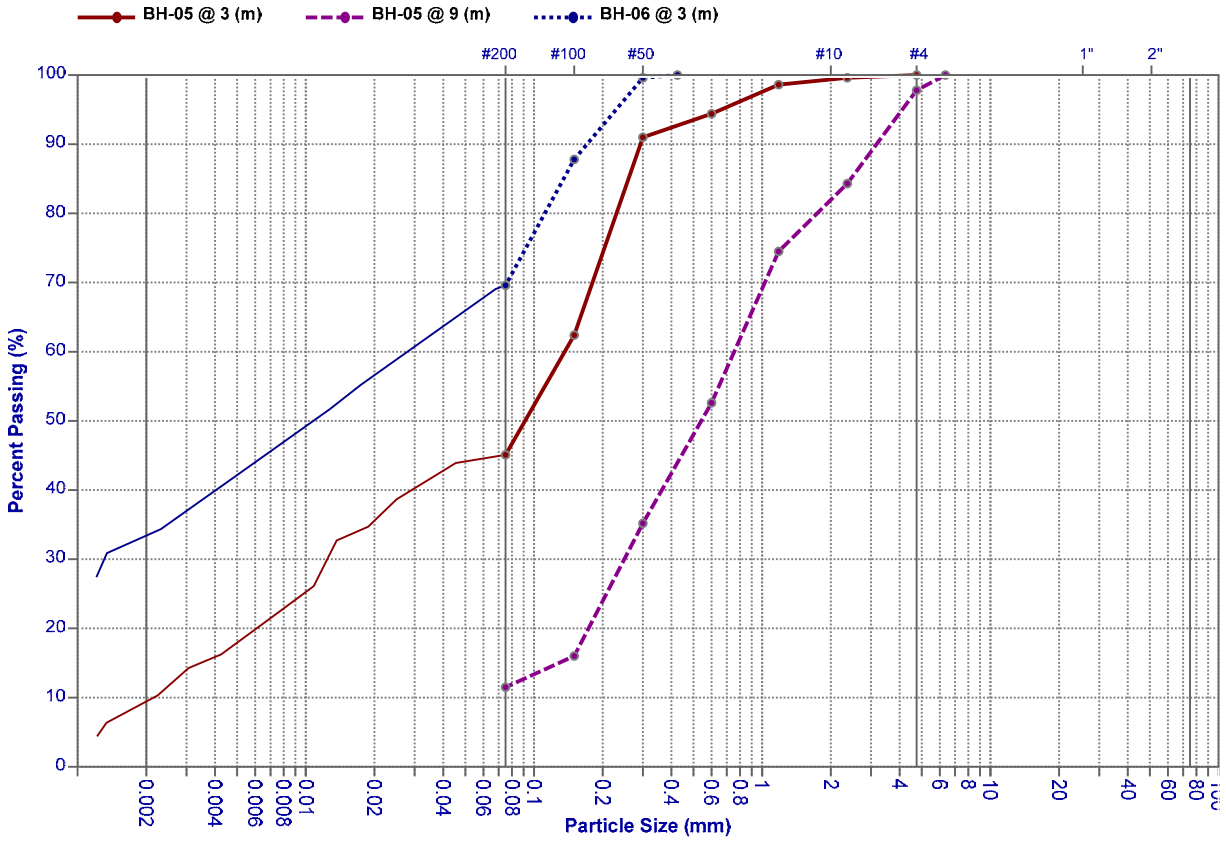
LTP-3

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
9.4	35.7	54.9	-	-
-	11.5	86.3	2.2	-
33.4	36.2	30.4	-	-

Classification

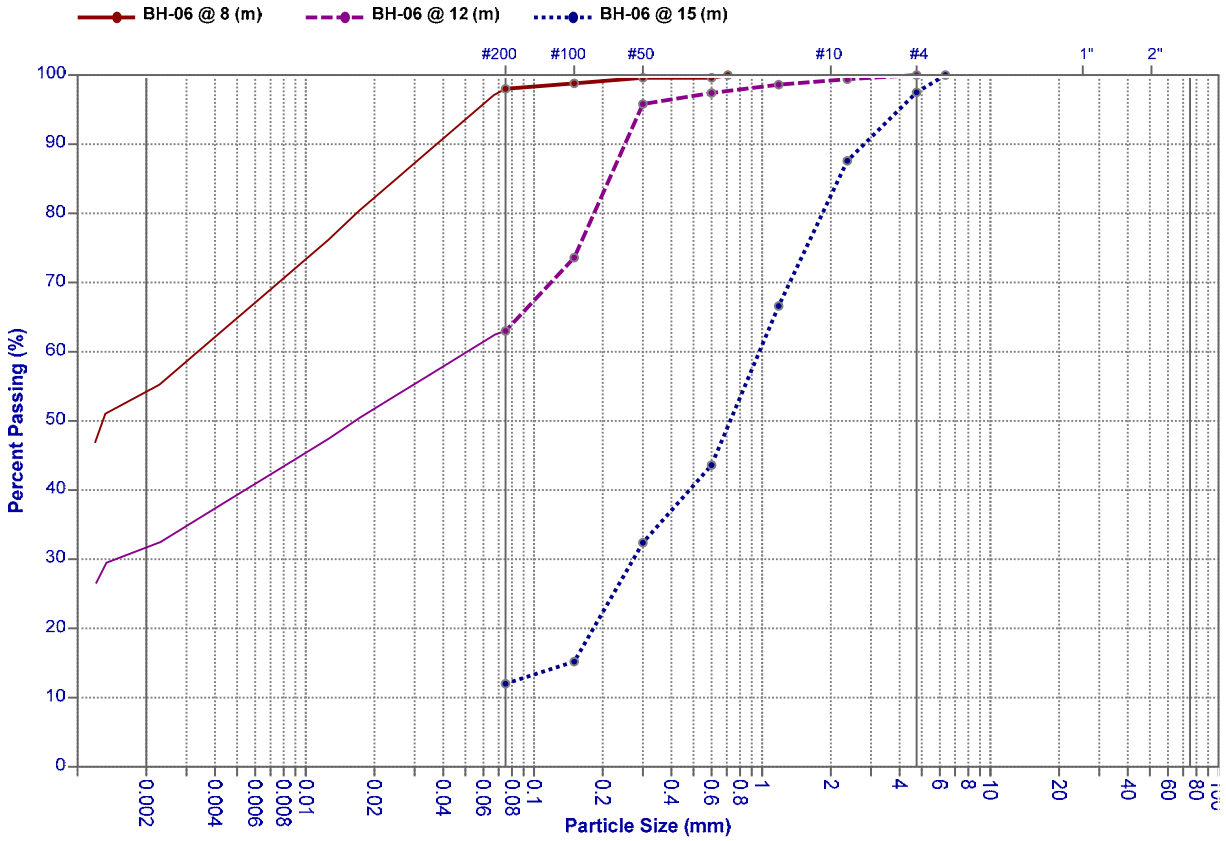
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-05	3	0.002	0.012	0.091	0.136	0.529	68	-	-	N/A	SM	A-4
BH-05	9	-	0.249	0.541	0.754	1.082	-	-	-	N/A	SW-SM	A-2-4
BH-06	3	0.001	0.001	0.011	0.028	0.036	28	21.4	3.2	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
54.2	43.8	2	-	-
31.7	31.3	37	-	-
-	12	85.5	2.5	-

Classification

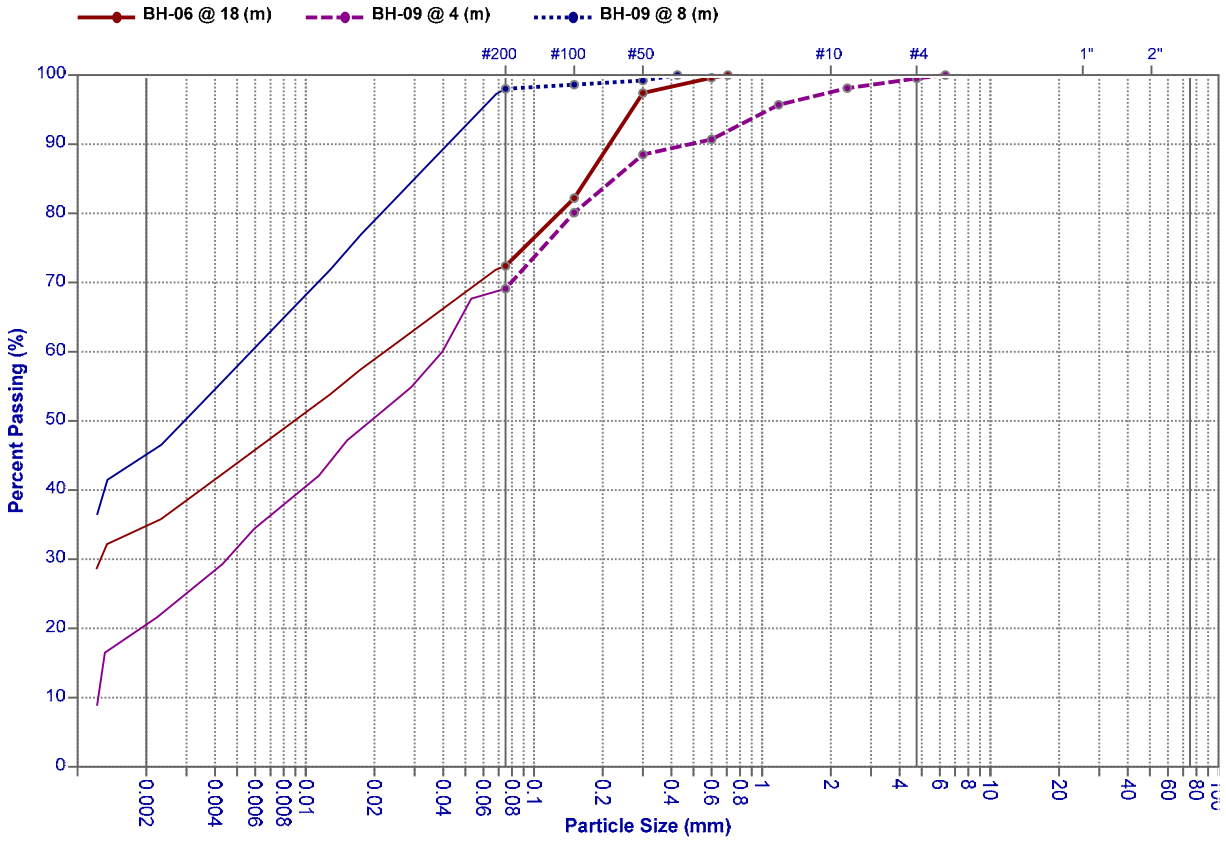
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-06	8	0.001	0.001	0.001	0.003	0.333	3	31.7	9.6	N/A	CL	A-4
BH-06	12	0.001	0.001	0.016	0.051	0.02	51	26.3	5.4	N/A	CL-ML	A-4
BH-06	15	-	0.272	0.724	0.972	1.002	-	-	-	N/A	SM	A-1-b

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
34.8	37.6	27.6	-	-
20.6	48.5	30.4	0.5	-
45.1	52.9	2	-	-

Classification

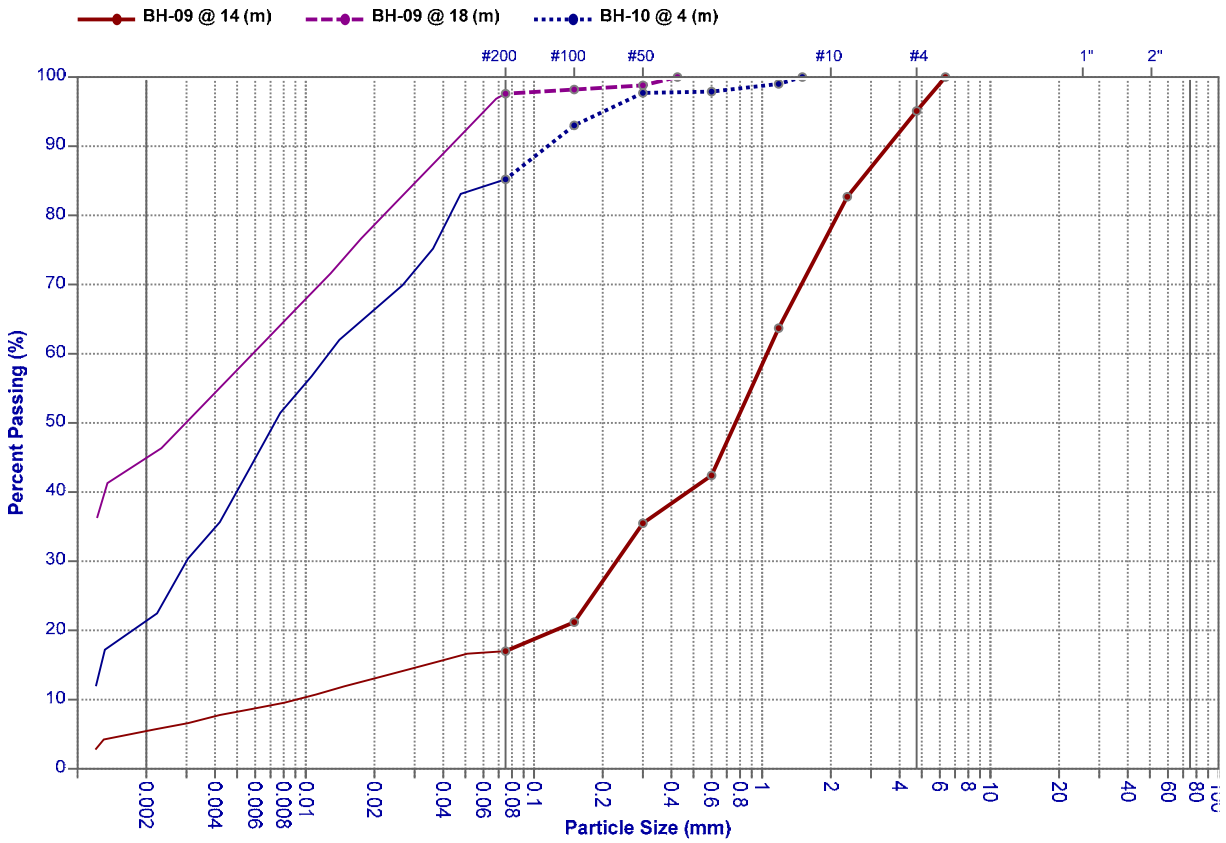
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-06	18	0.001	0.001	0.009	0.022	0.045	22	35.2	8.5	N/A	ML	A-4
BH-09	4	0.001	0.005	0.019	0.04	0.625	40	-	-	N/A	ML	A-4
BH-09	8	0.001	0.001	0.003	0.006	0.167	6	31.5	4.2	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
5.5	11.5	78.1	4.9	-
44.9	52.7	2.4	-	-
21.4	63.8	14.8	-	-

Classification

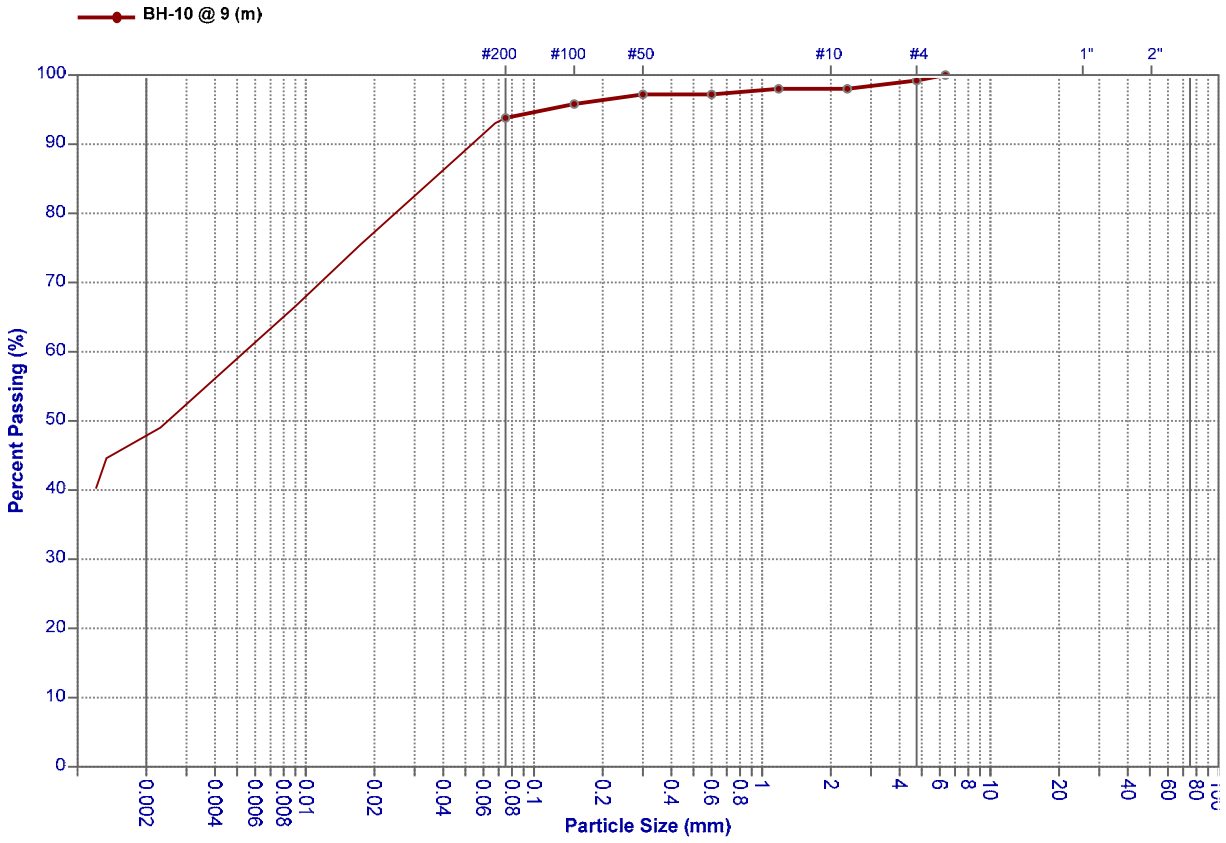
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-09	14	0.009	0.23	0.764	1.049	5.603	116.556	-	-	N/A	SM	A-1-b
BH-09	18	0.001	0.001	0.003	0.006	0.167	6	31.7	2.8	N/A	ML	A-4
BH-10	4	0.001	0.003	0.007	0.013	0.692	13	-	-	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
47.9	45.9	5.4	0.8	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-10	9	0.001	0.001	0.002	0.005	0.2	5	28.9	6.8	N/A	CL-ML	A-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	3 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

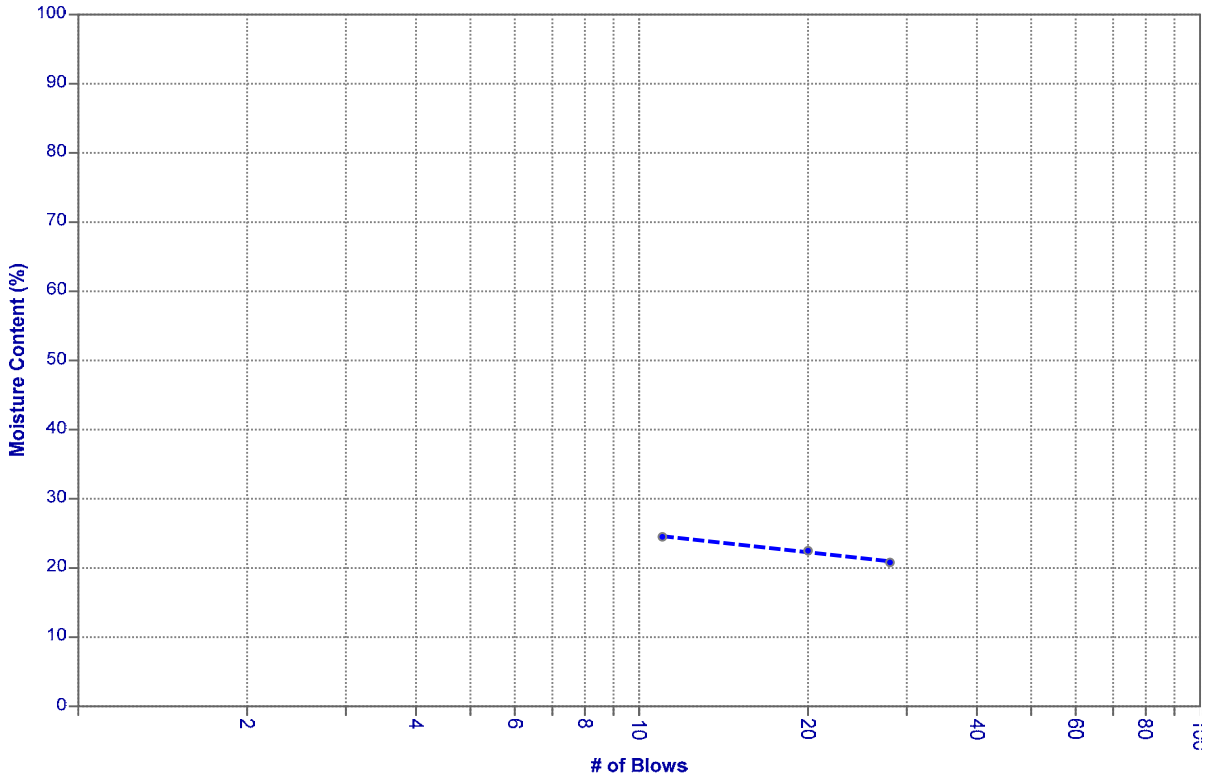
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.8	26.6	22.7	11	24.5
6.7	24.1	20.9	20	22.5
7.1	27.4	23.9	28	20.8
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	17.3	15.7	18.2

LL = 21.4 % **PL = 18.2 %** **PI=3.2**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8 (m)
Job No.:	K19-1092-101	Classification :	CL
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

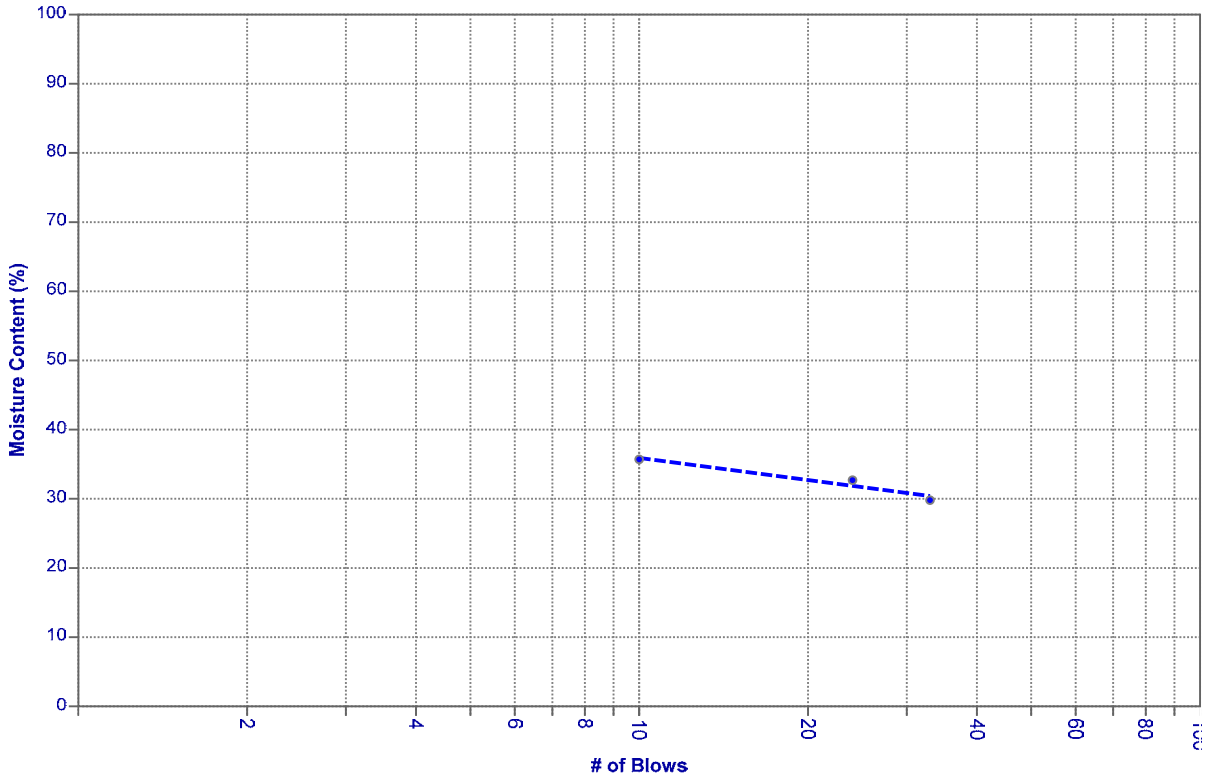
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	20.2	16.7	10	35.7
7	20.8	17.4	24	32.7
6.6	24.9	20.7	33	29.8
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7	17.5	15.6	22.1

LL = 31.7 % **PL = 22.1 %** **PI=9.6**



Unified Description : Low Plasticity Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	12 (m)
Job No.:	K19-1092-101	Classification :	CL-ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

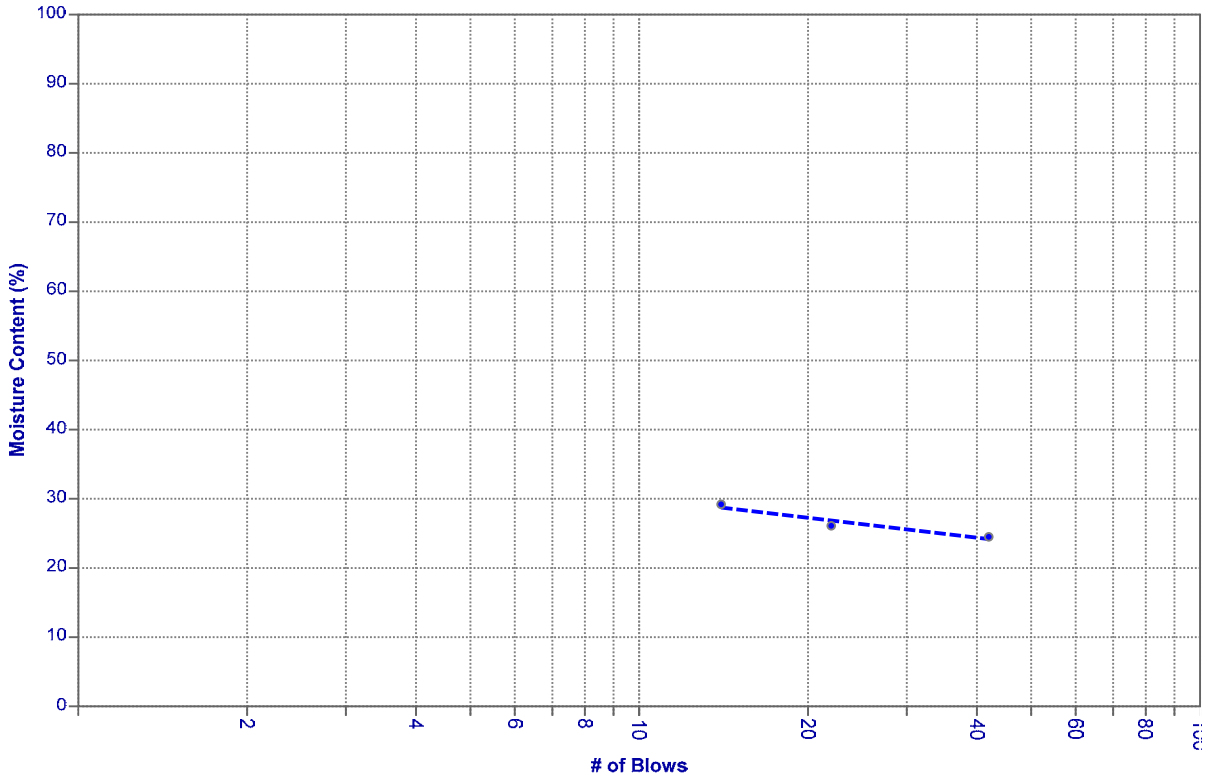
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.7	21.3	18	14	29.2
6.8	21.8	18.7	22	26.1
6.6	19.8	17.2	42	24.5
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7	18	16.1	20.9

LL = 26.3 % **PL = 20.9 %** **PI=5.4**



Unified Description : Silty Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	18 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-4318

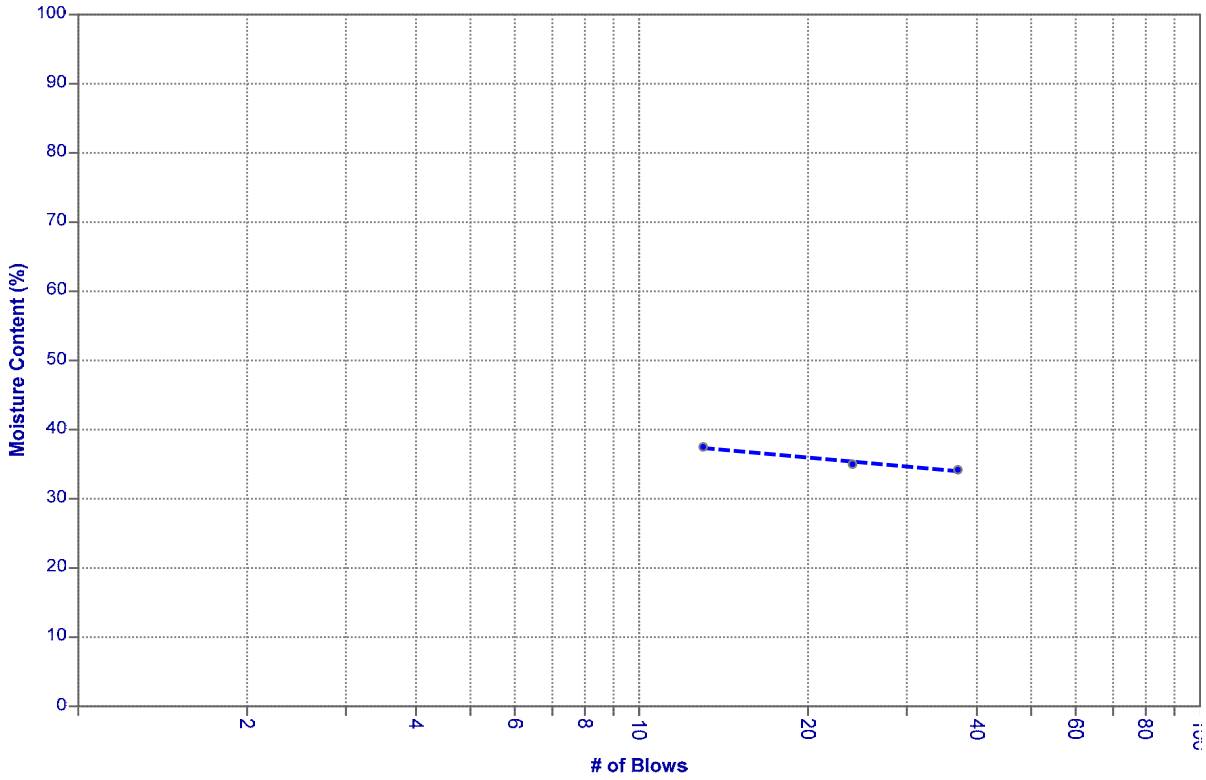
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	23.4	18.9	13	37.5
6.8	20.7	17.1	24	35
6.8	22.9	18.8	37	34.2
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.6	16.1	14.1	26.7

LL = 35.2 % **PL = 26.7 %** **PI=8.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-09
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

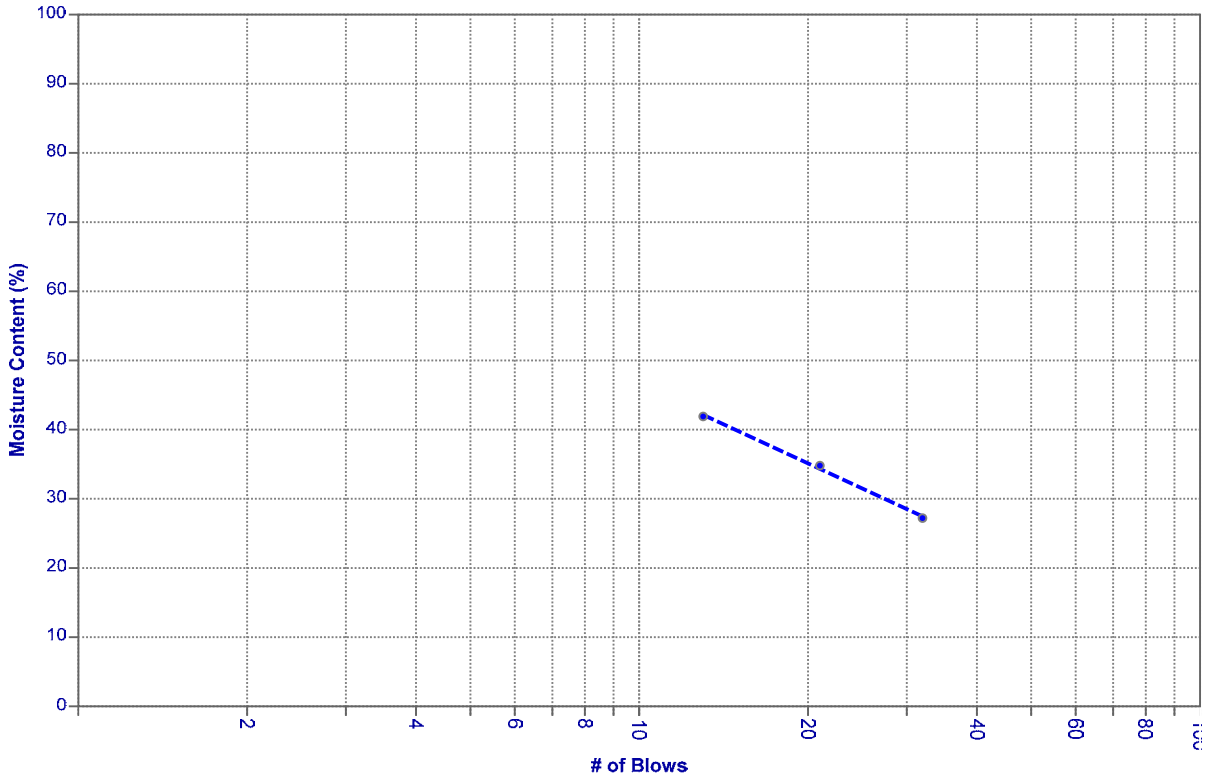
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.4	23	18.1	13	41.9
6.6	18.6	15.5	21	34.8
6.5	19.6	16.8	32	27.2
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	15.3	13.5	27.3

LL = 31.5 % **PL = 27.3 %** **PI=4.2**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-09
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	18 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-4318

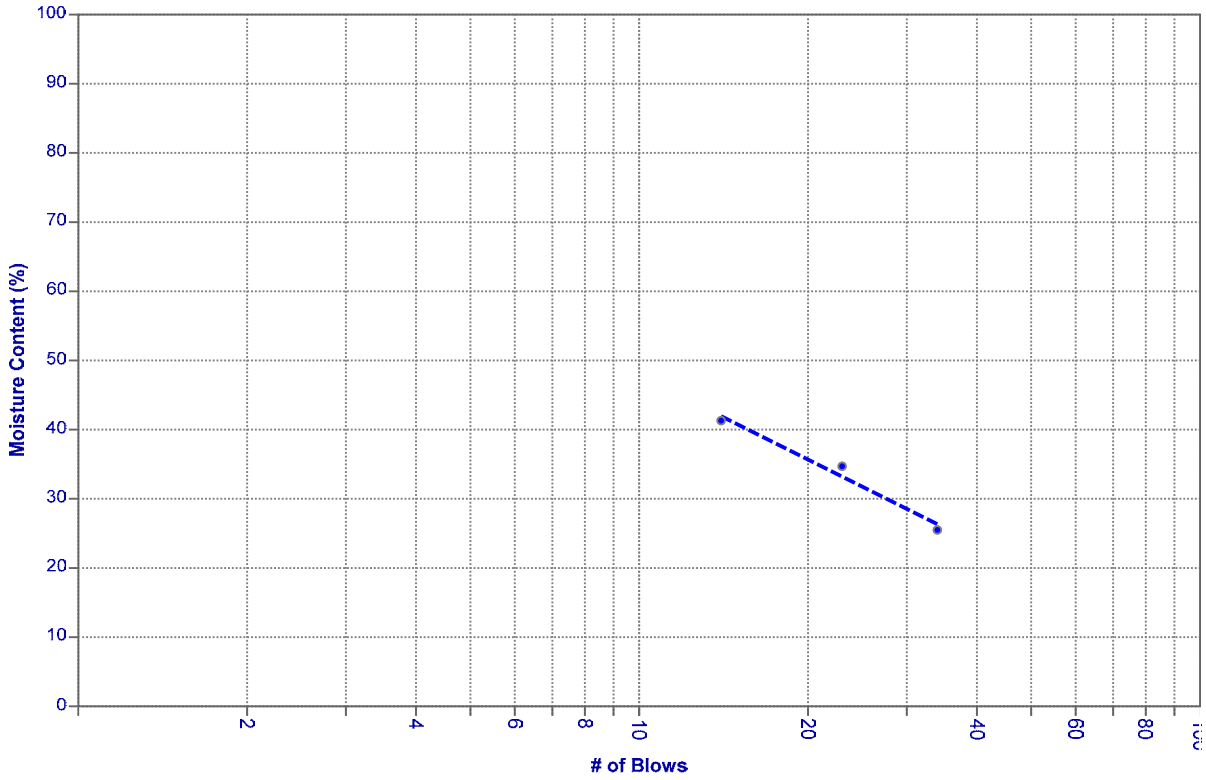
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7	22.4	17.9	14	41.3
6.9	20.5	17	23	34.7
6.8	20.1	17.4	34	25.5
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	16.7	14.5	28.9

LL = 31.7 % **PL = 28.9 %** **PI=2.8**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-10
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	9 (m)
Job No.:	K19-1092-101	Classification :	CL-ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

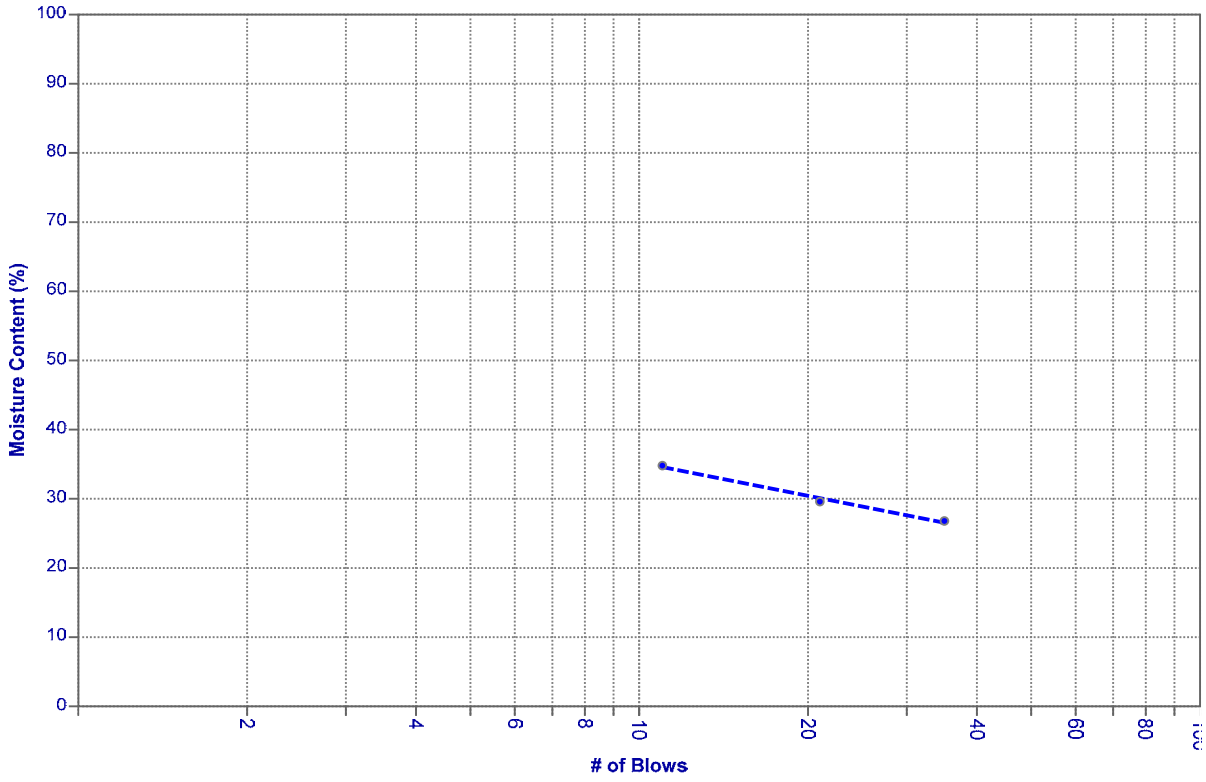
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.7	24.5	19.9	11	34.8
7.2	17.7	15.3	21	29.6
7.1	24.6	20.9	35	26.8
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.6	18.2	16.1	22.1

LL = 28.9 % **PL = 22.1 %** **PI=6.8**



Unified Description : Silty Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-06	18	24.78	1.52	1.9
BH-09	18	23.79	1.55	1.92

Unconfined Compression Test

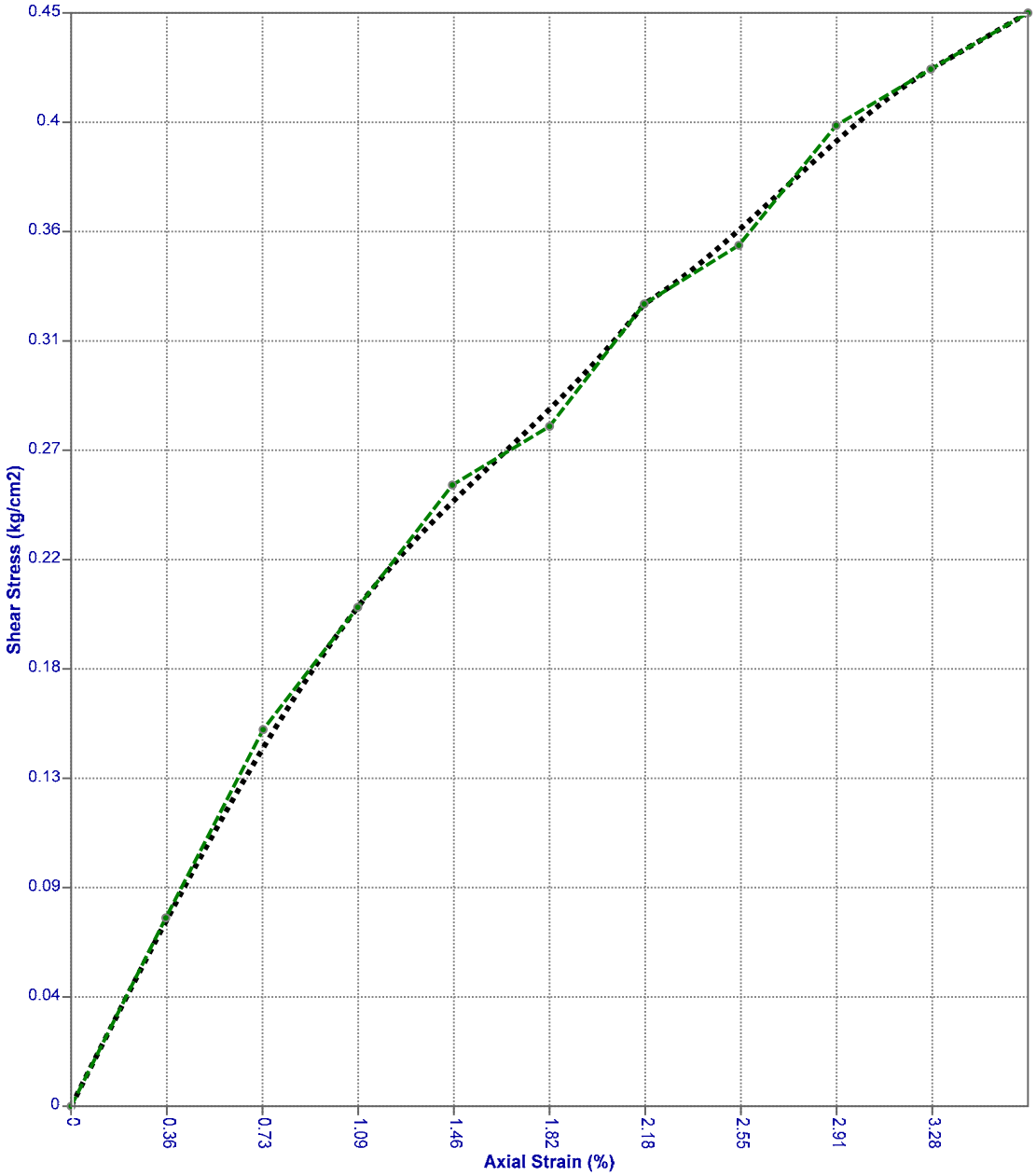
Project :	GI for Yellow BRTS Line	Borehole :	BH-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	18 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
7.027	13.754	2	Moist	24.78	1.52	0.45	0.22



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Unconfined Compression Test

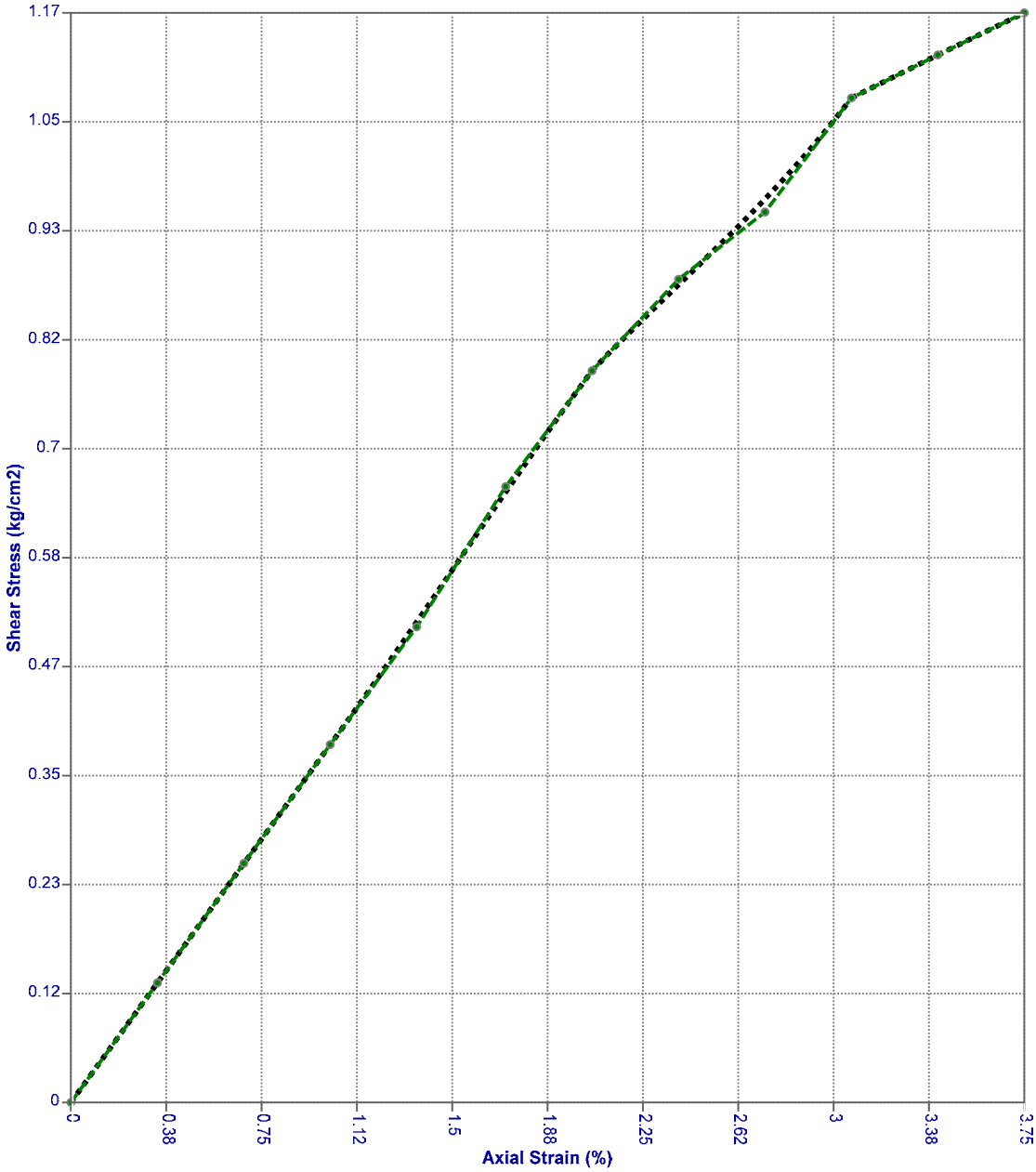
Project :	GI for Yellow BRTS Line	Borehole :	BH-09
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	18 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
7.027	14.657	2	Moist	23.79	1.55	1.17	0.58



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

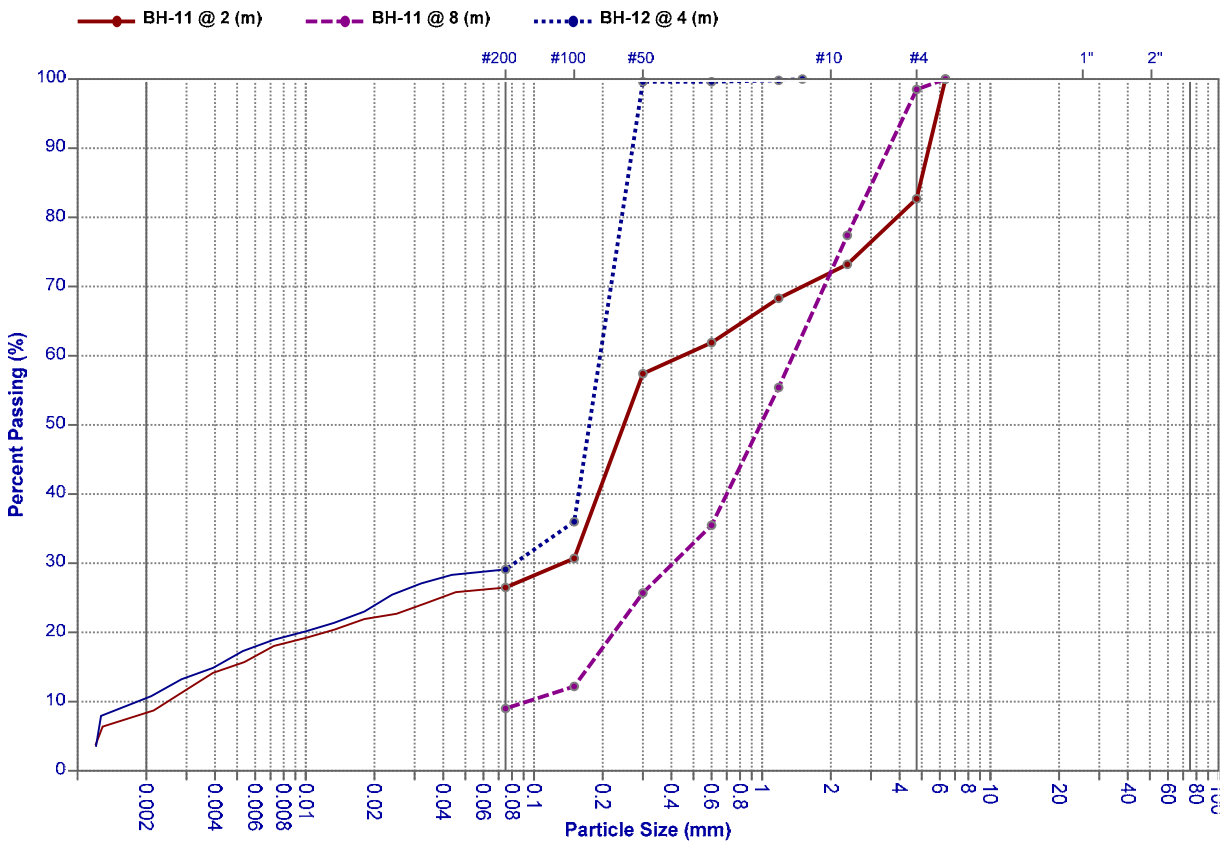
LTP-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
8.4	18.1	56.2	17.3	-
-	9	89.5	1.5	-
10.5	18.6	70.9	-	-

Classification

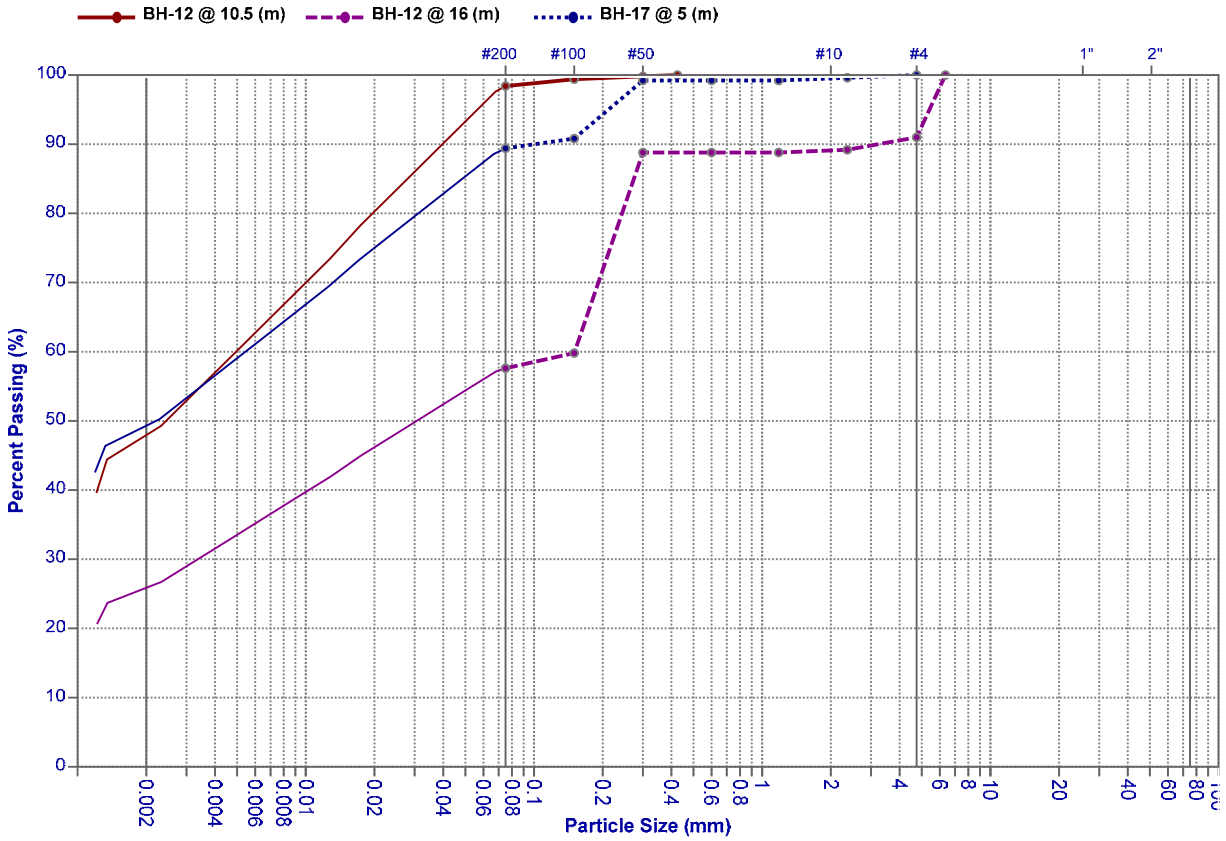
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-11	2	0.002	0.134	0.248	0.448	20.04	224	-	-	N/A	SM	A-2-4
BH-11	8	0.093	0.407	0.982	1.364	1.306	14.667	-	-	N/A	SW-SM	A-1-b
BH-12	4	0.002	0.082	0.175	0.195	17.241	97.5	-	-	N/A	SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
47.9	50.5	1.6	-	-
25.9	31.7	33.4	9	-
49.3	40.1	10.6	-	-

Classification

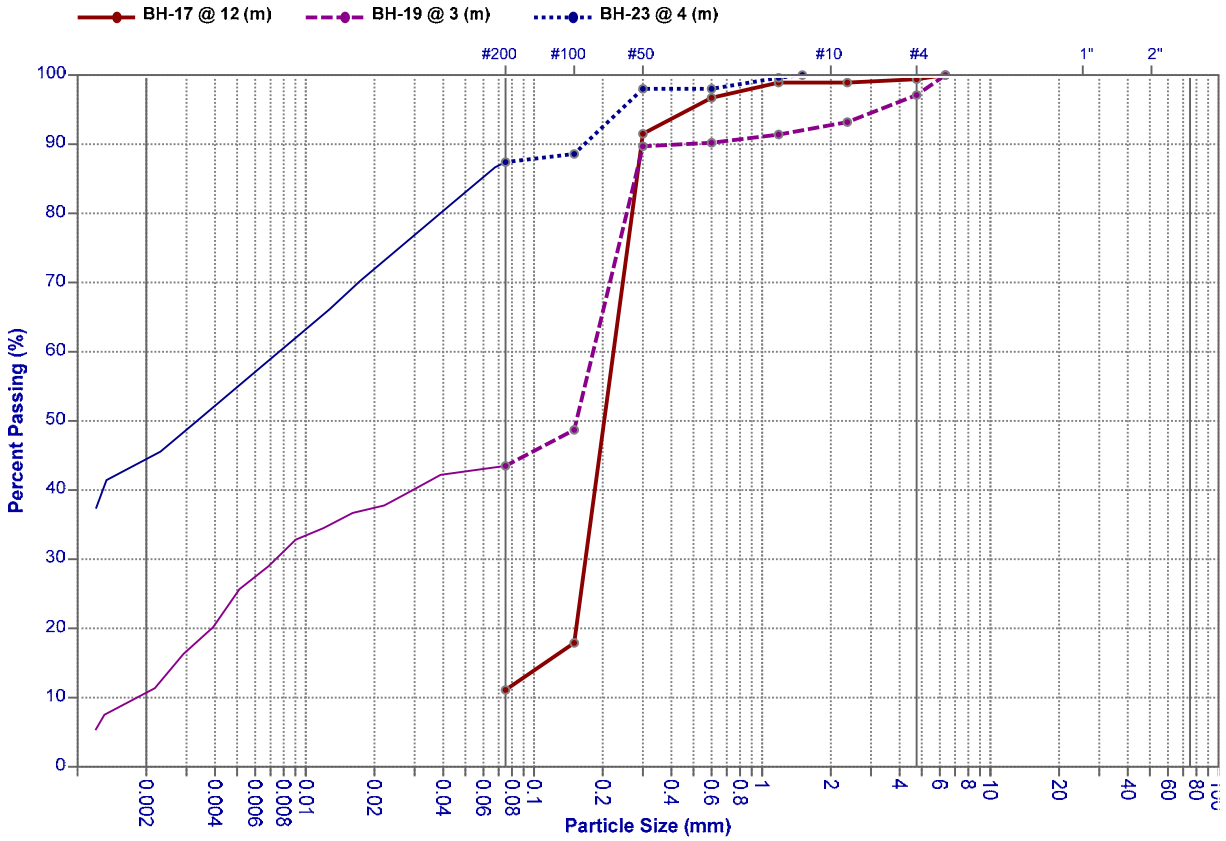
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-12	10.5	0.001	0.001	0.002	0.005	0.2	5	19.3	3.5	N/A	ML	A-4
BH-12	16	0.001	0.003	0.031	0.151	0.06	151	14.5	1.4	N/A	ML	A-4
BH-17	5	0.001	0.001	0.002	0.005	0.2	5	22.4	7.4	N/A	CL	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	11.1	88.3	0.6	-
10.7	32.8	53.6	2.9	-
44.5	42.9	12.6	-	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-17	12	-	0.168	0.203	0.223	1.665	-	-	-	N/A	SP-SM	A-2-4
BH-19	3	0.002	0.007	0.153	0.182	0.135	91	-	-	N/A	SM	A-4
BH-23	4	0.001	0.001	0.003	0.008	0.125	8	28.5	6.8	N/A	CL-ML	A-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-12
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	10.5 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

ASTM D-4318

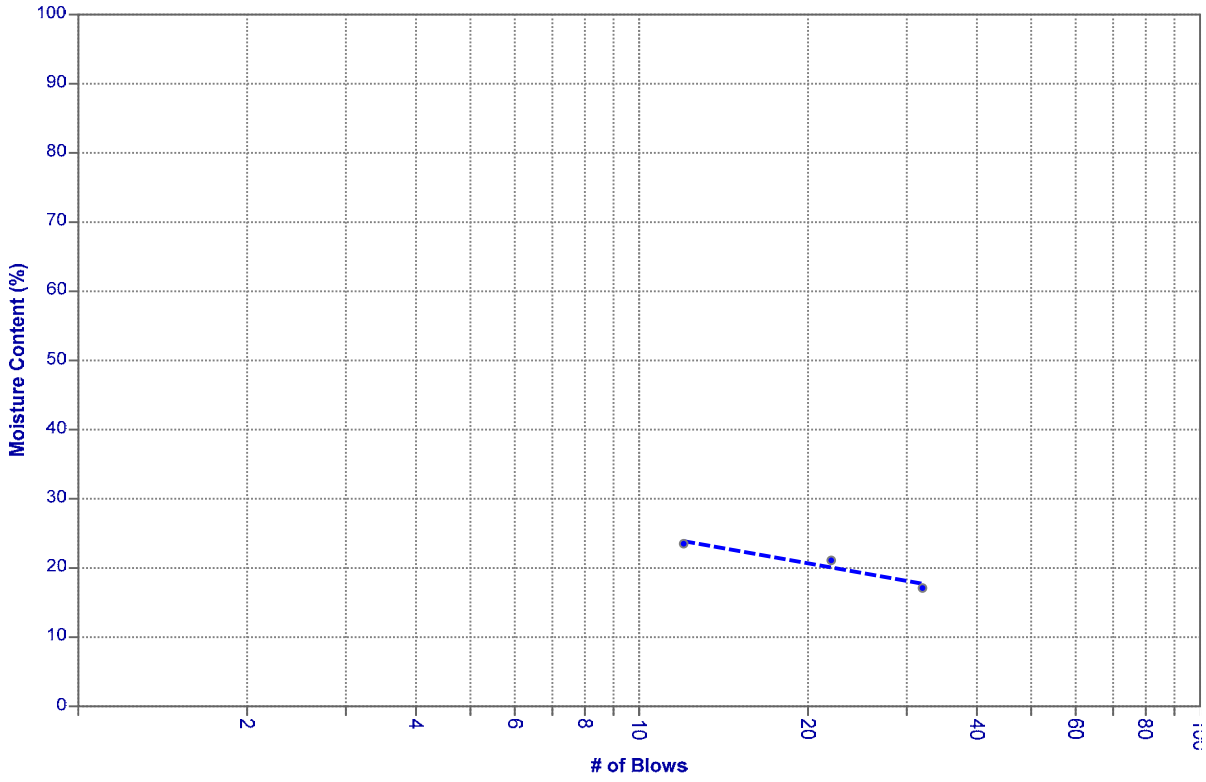
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	19.65	17.22	12	23.5
7.5	25.45	22.32	22	21.1
6.8	26.78	23.86	32	17.1
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	18.5	16.9	15.8

LL = 19.3 % **PL = 15.8 %** **PI=3.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-12
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	16 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

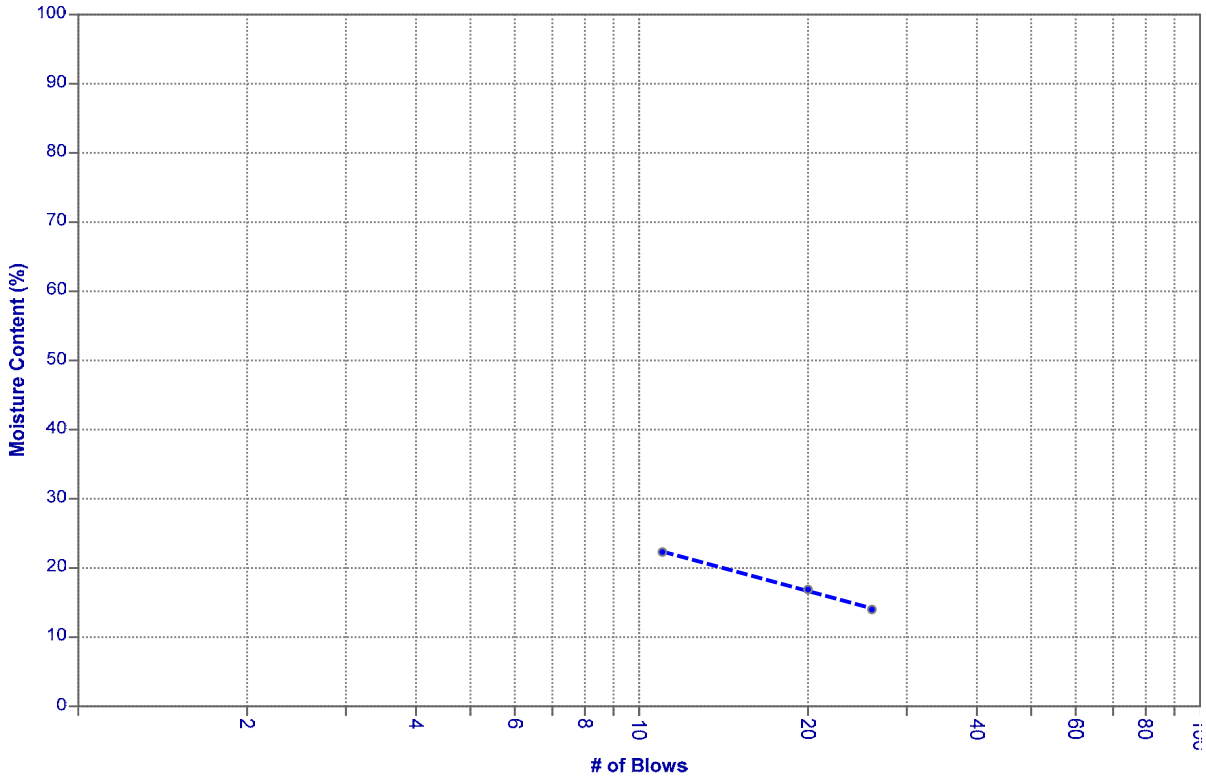
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.6	18.1	16	11	22.3
6.7	26.8	23.9	20	16.9
6.8	25.4	23.11	26	14
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	15.17	14.2	13.1

LL = 14.5 % **PL = 13.1 %** **PI=1.4**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-17
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	5 (m)
Job No.:	K19-1092-101	Classification :	CL
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

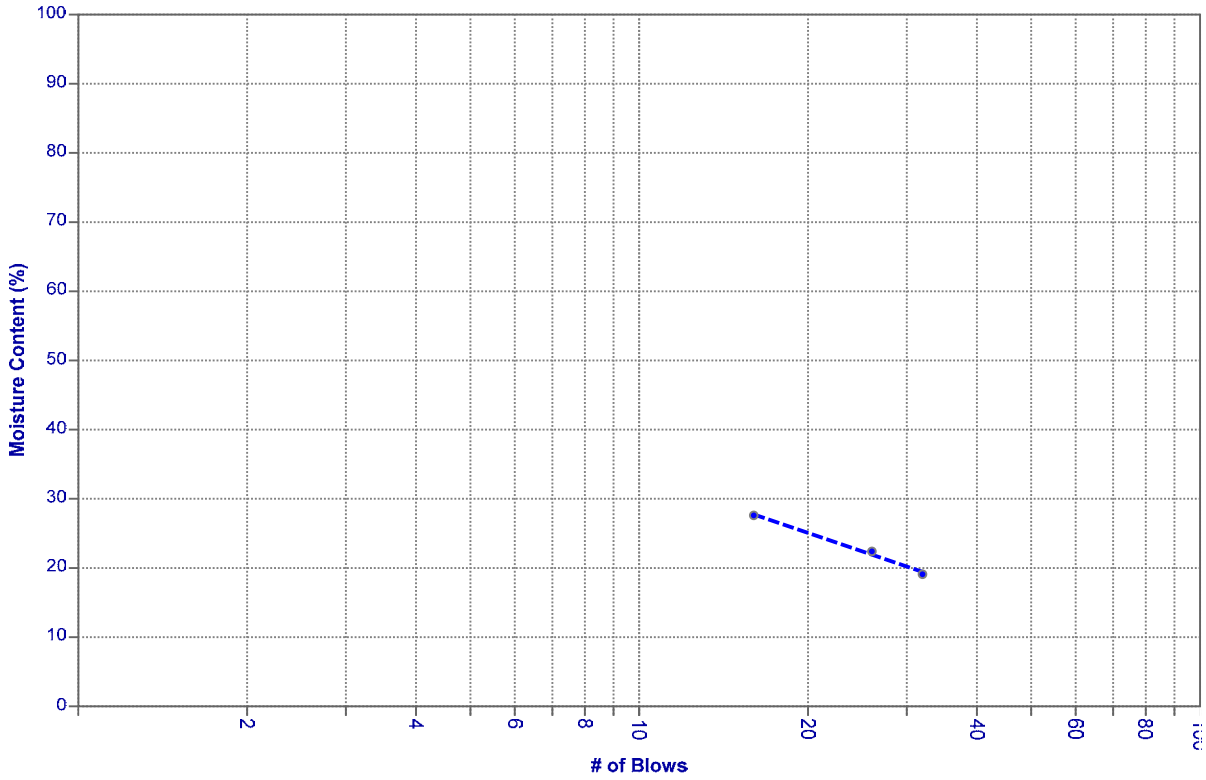
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	29.12	24.32	16	27.6
6.8	28.66	24.66	26	22.4
7.2	32.12	28.12	32	19.1
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	18.9	17.32	15

LL = 22.4 % **PL = 15 %** **PI=7.4**



Unified Description : Low Plasticity Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-23
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4 (m)
Job No.:	K19-1092-101	Classification :	CL-ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

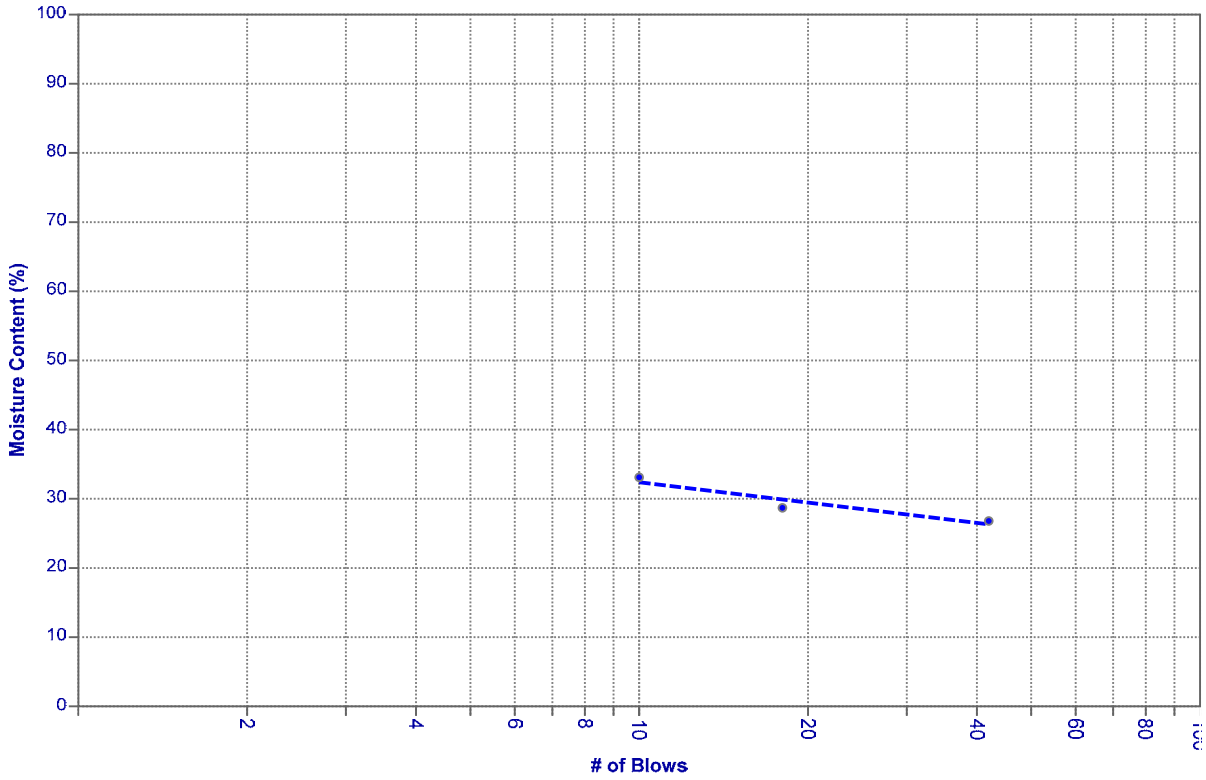
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.7	22.4	18.5	10	33.1
7	20.9	17.8	18	28.7
6.8	22.4	19.1	42	26.8
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	18	16	21.7

LL = 28.5 % **PL = 21.7 %** **PI=6.8**



Unified Description : Silty Clay With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-12	10.5	19.81	1.59	1.9

Unconfined Compression Test

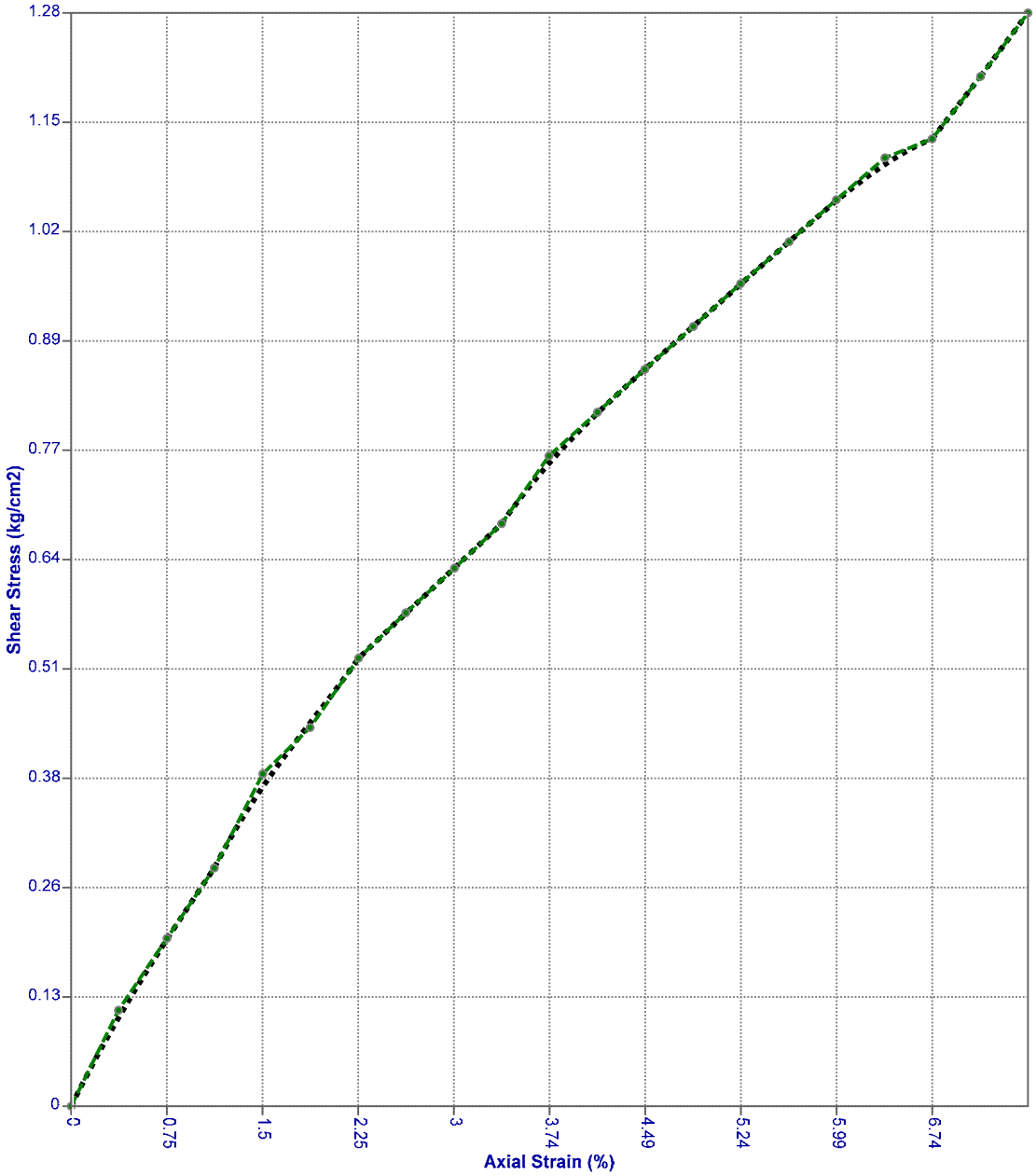
Project :	GI for Yellow BRTS Line	Borehole :	BH-12
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	10.5 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
6.726	13.352	2	Moist	19.81	1.59	1.28	0.64



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Unconfined Compression Test

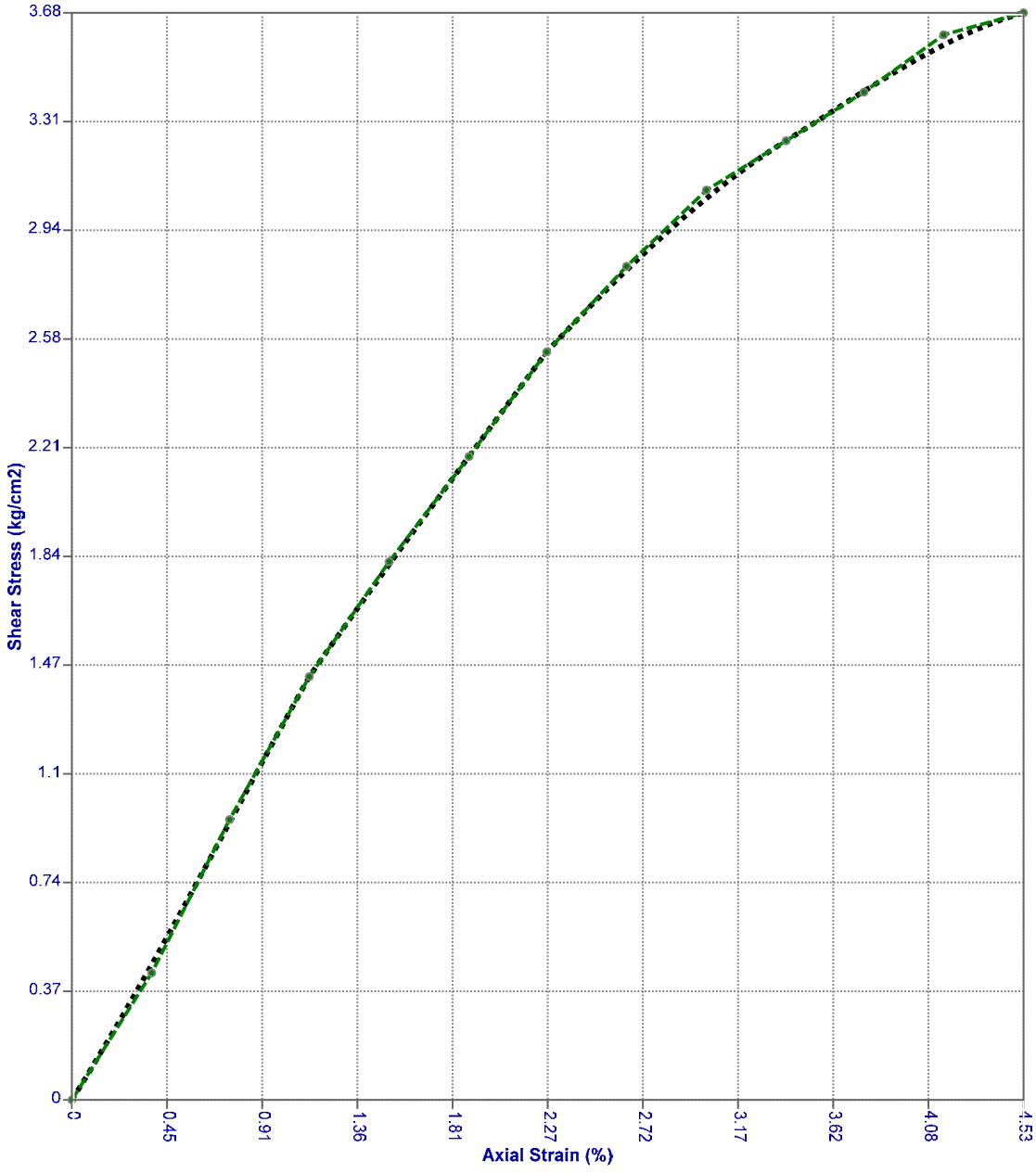
Project :	GI for Yellow BRTS Line	Borehole :	BH-23
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	9.3 (m)
Job No.:	K19-1092-101	Rock Name :	Claystone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
6.426	13.252	2	Moist	18.66	1.68	3.68	1.84



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

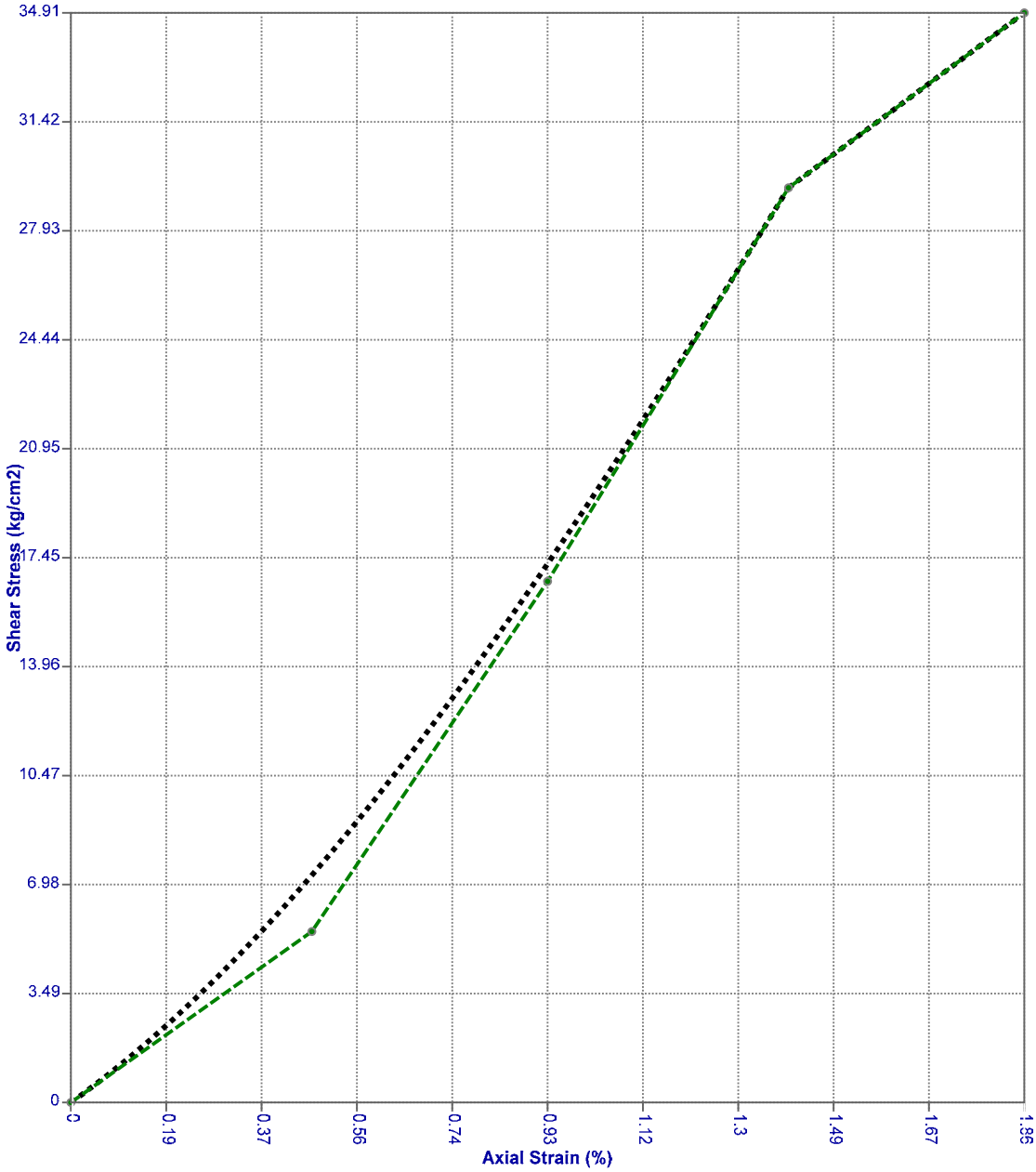
Project :	GI for Yellow BRTS Line	Borehole :	BH-23
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	12.49 (m)
Job No.:	K19-1092-101	Rock Name :	Mudstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.421	10.742	2	Moist	11.52	2.07	34.91	17.45



Unified Description :
AASHTO Description :

Tested By :

1D Consolidation Test

Project :	GI for Yellow BRTS Line	Borehole :	BH-12
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	10.5 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

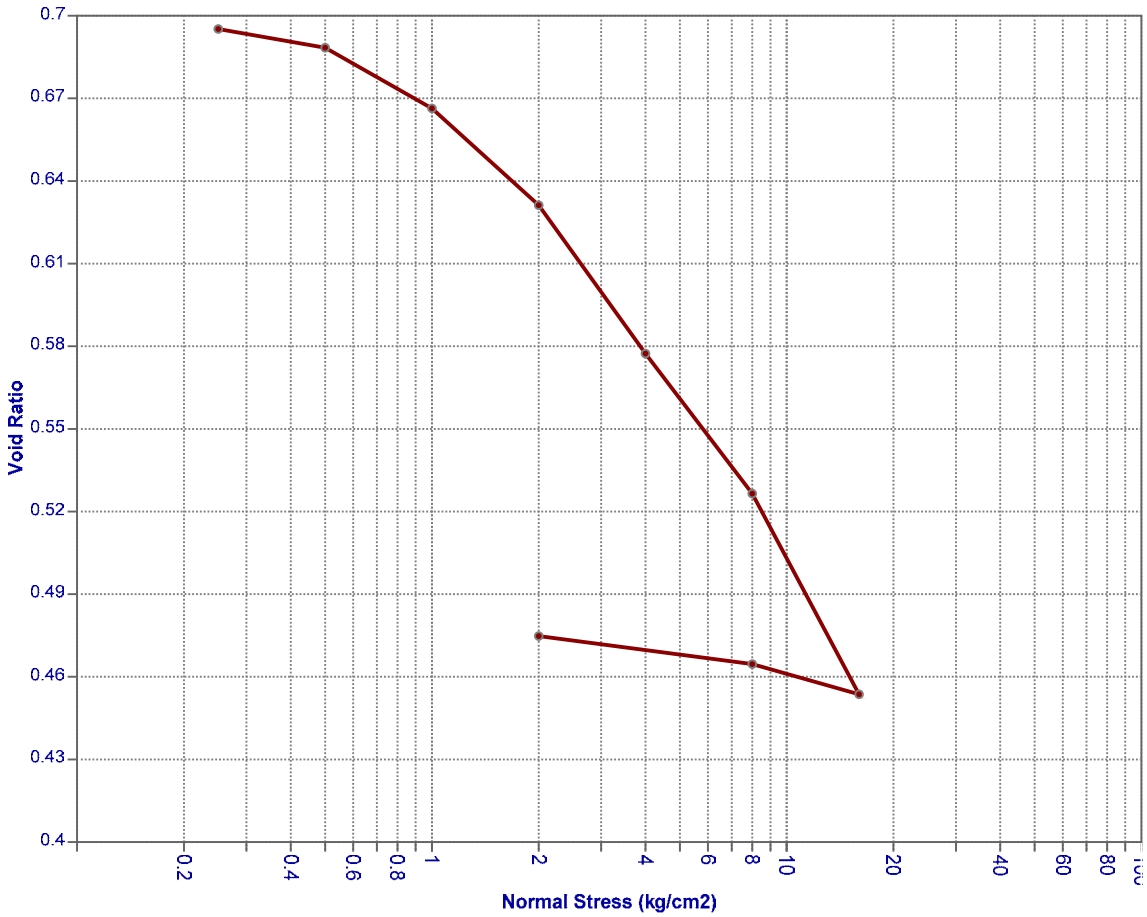
ASTM D2435

Sample Info

Diameter (cm)	Height (cm)	Dry Weight (gr)	Wet Weight Before (gr)	Wet Weight After (gr)	Void Ratio	Gs
6	2	88.4	108	111	0.7	2.65

Compression Parameters

Cc	Cs	Pre-Consolidation Pressure (kg/cm2)
0.31	0.02	4.99



Mv Values

P1 (kg/cm2)	P2 (kg/cm2)	e1	e2	Mv 1/ (kg/cm2)
0.25	0.5	0.695	0.688	1.60E-002
0.5	1	0.688	0.666	2.61E-002
1	2	0.666	0.631	2.11E-002
2	4	0.631	0.577	1.65E-002
4	8	0.577	0.527	8.06E-003
8	16	0.527	0.454	5.97E-003

Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By : HH

Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D516, D512, D1293

Borehole	Sample Depth (m)	Description	Value
BH-12	10.5	Sulphate Content (%)	0.01
BH-12	10.5	Chloride Content (%)	0.19
BH-12	10.5	Organic Matter (%)	3.2

Water Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

Soil Testing Services

ASTM D-1293, D-516
D-512, D-5907

Borehole	Sample	Sample Depth (m)	Total Salt Content (ppm)	Chloride Content (ppm)	Sulphate (ppm)	pH Values
BH-12	WS-1	13.00	1910	844	171	7.88

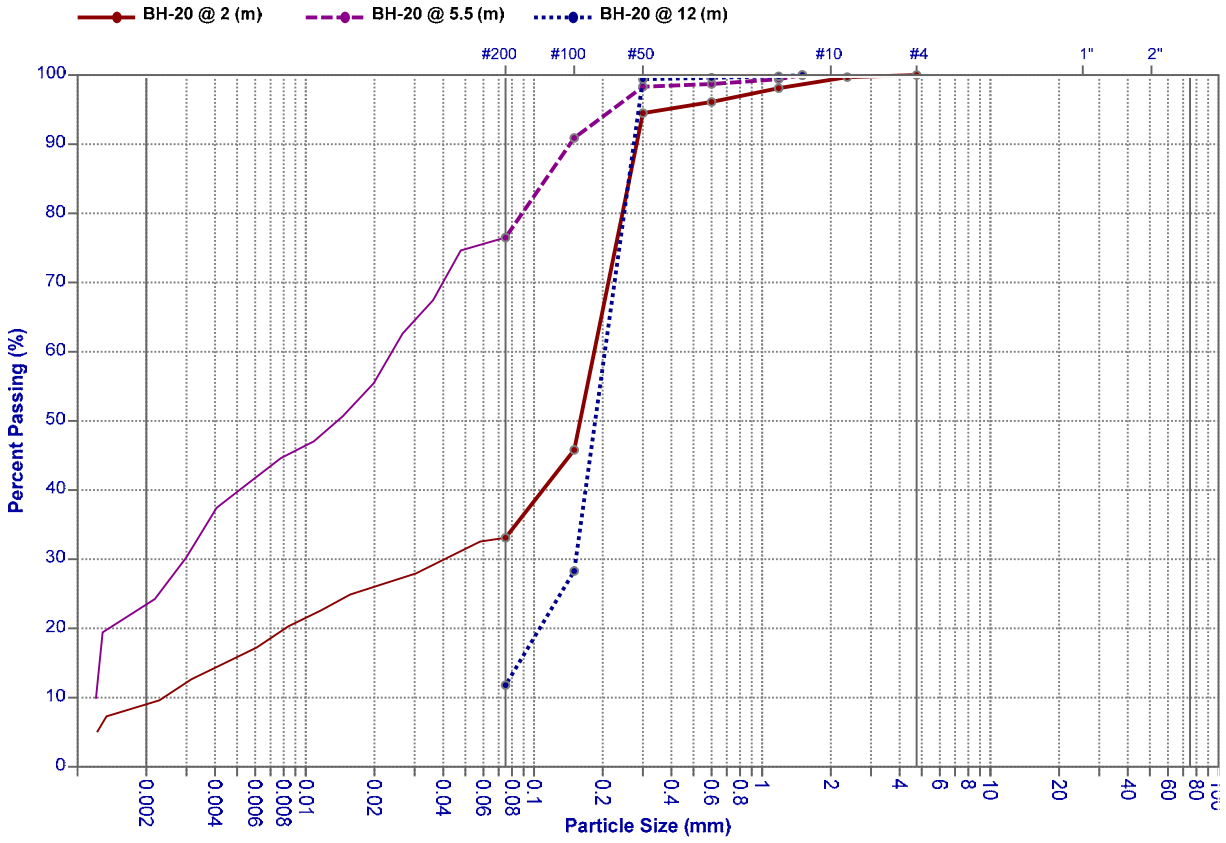
LTP-5

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
9	24.1	66.9	-	-
23.5	53	23.5	-	-
-	11.8	88.2	-	-

Classification

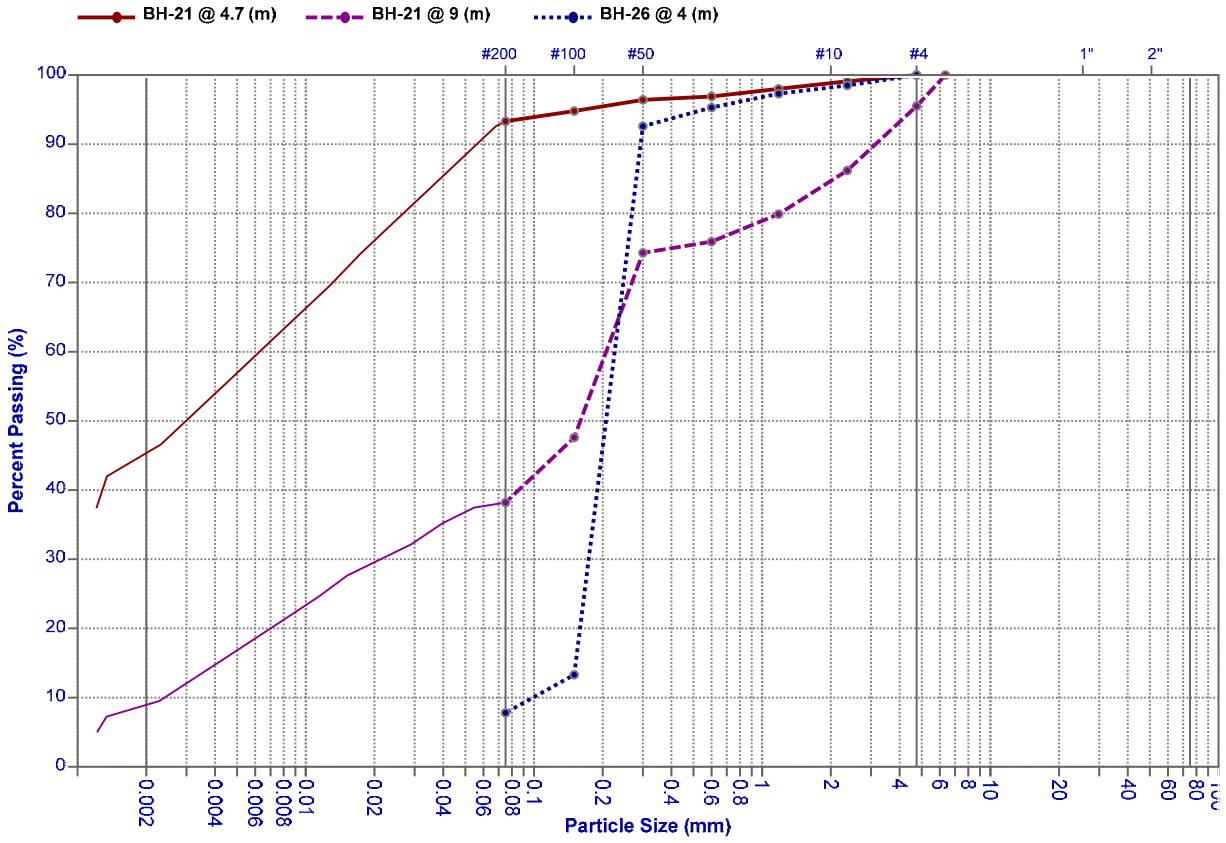
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-20	2	0.002	0.041	0.159	0.184	4.568	92	-	-	N/A	SM	A-2-4
BH-20	5.5	0.001	0.003	0.014	0.024	0.375	24	-	-	N/A	ML	A-4
BH-20	12	-	0.153	0.185	0.204	1.51	-	-	-	N/A	SP-SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
45.3	48	6.7	-	-
8.9	29.3	57.3	4.5	-
-	7.8	92.2	-	-

Classification

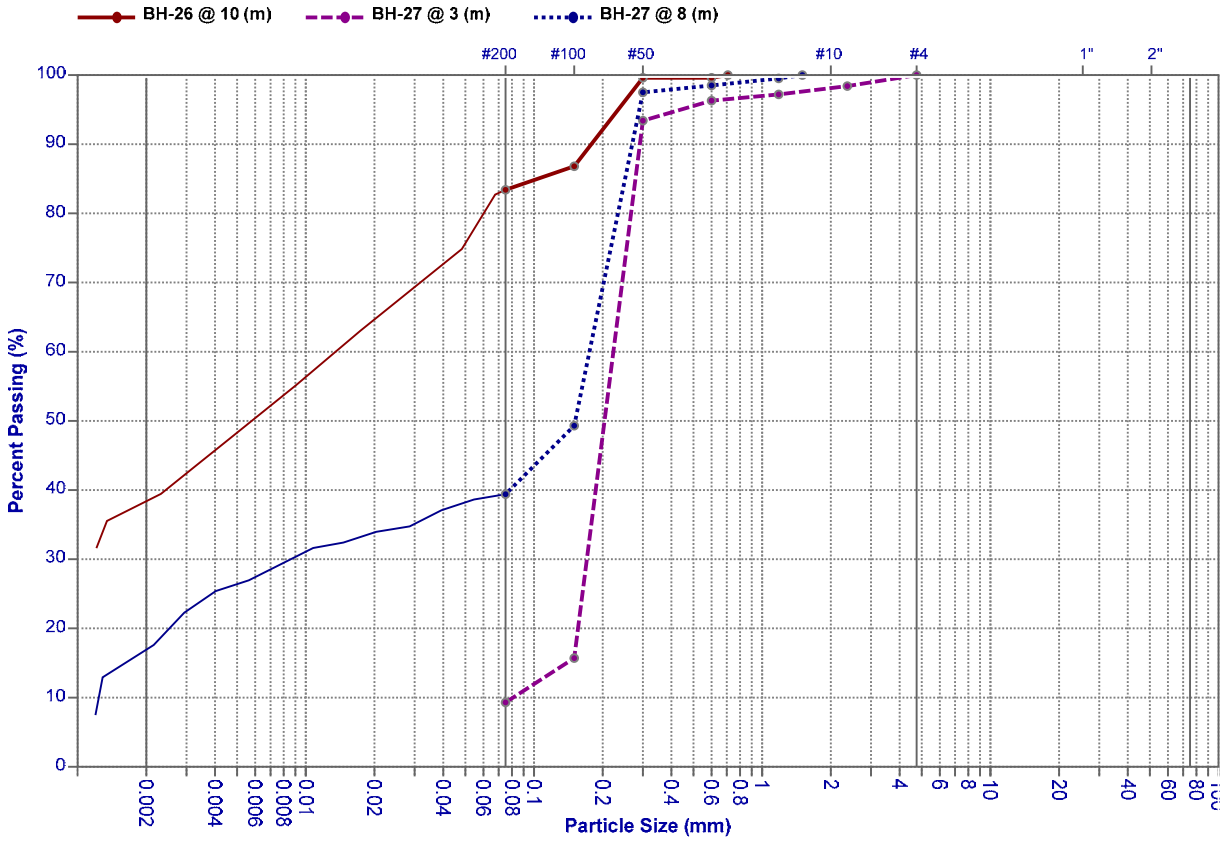
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-21	4.7	0.001	0.001	0.003	0.006	0.167	6	48.9	11.4	N/A	ML	A-7-5
BH-21	9	0.002	0.021	0.16	0.207	1.065	103.5	-	-	N/A	SM	A-4
BH-26	4	0.099	0.174	0.207	0.226	1.353	2.283	-	-	N/A	SP-SM	A-3

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
38.4	45	16.6	-	-
-	9.3	90.7	-	-
16.9	22.5	60.6	-	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-26	10	0.001	0.001	0.006	0.014	0.071	14	46	14.5	N/A	ML	A-7-5
BH-27	3	0.081	0.17	0.204	0.223	1.6	2.753	-	-	N/A	SP-SM	A-3
BH-27	8	0.001	0.009	0.152	0.175	0.463	175	-	-	N/A	SM	A-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-21
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4.7 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

ASTM D-4318

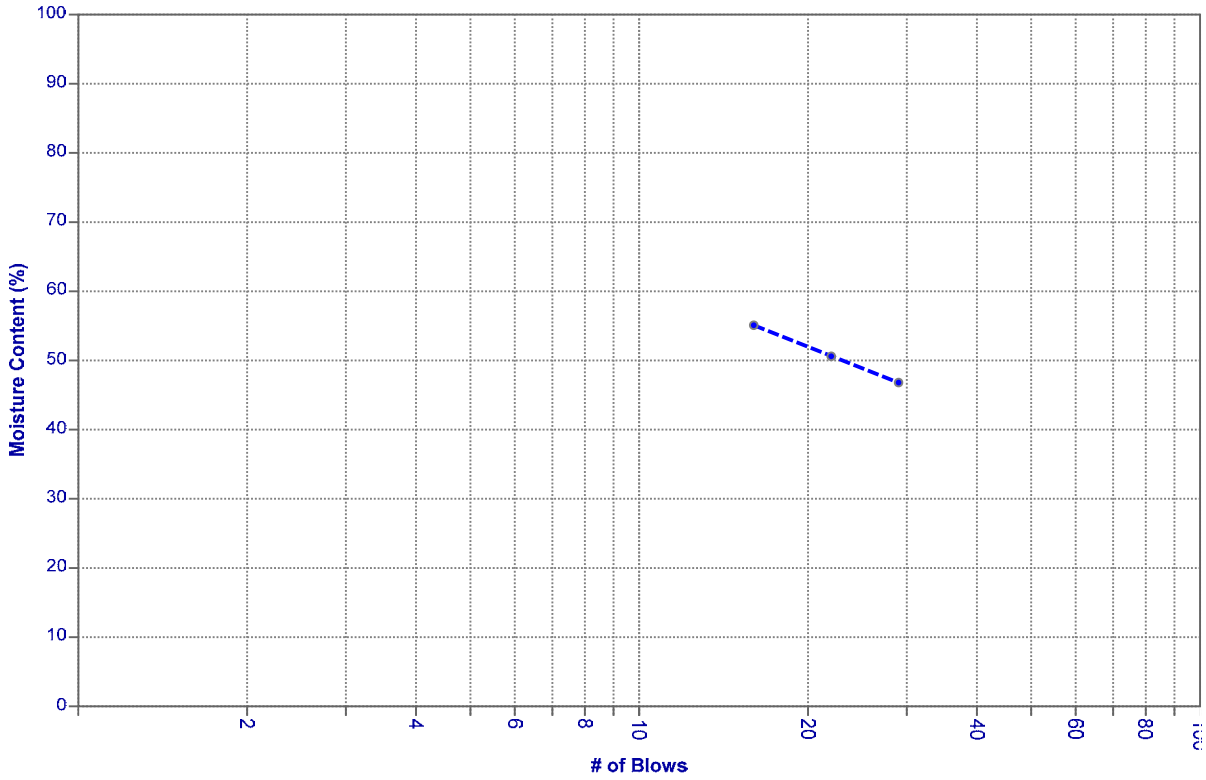
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.8	28.2	20.6	16	55.1
6.8	19.3	15.1	22	50.6
6.9	20.7	16.3	29	46.8
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7.1	17	14.3	37.5

LL = 48.9 % **PL = 37.5 %** **PI=11.4**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-26
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	10 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

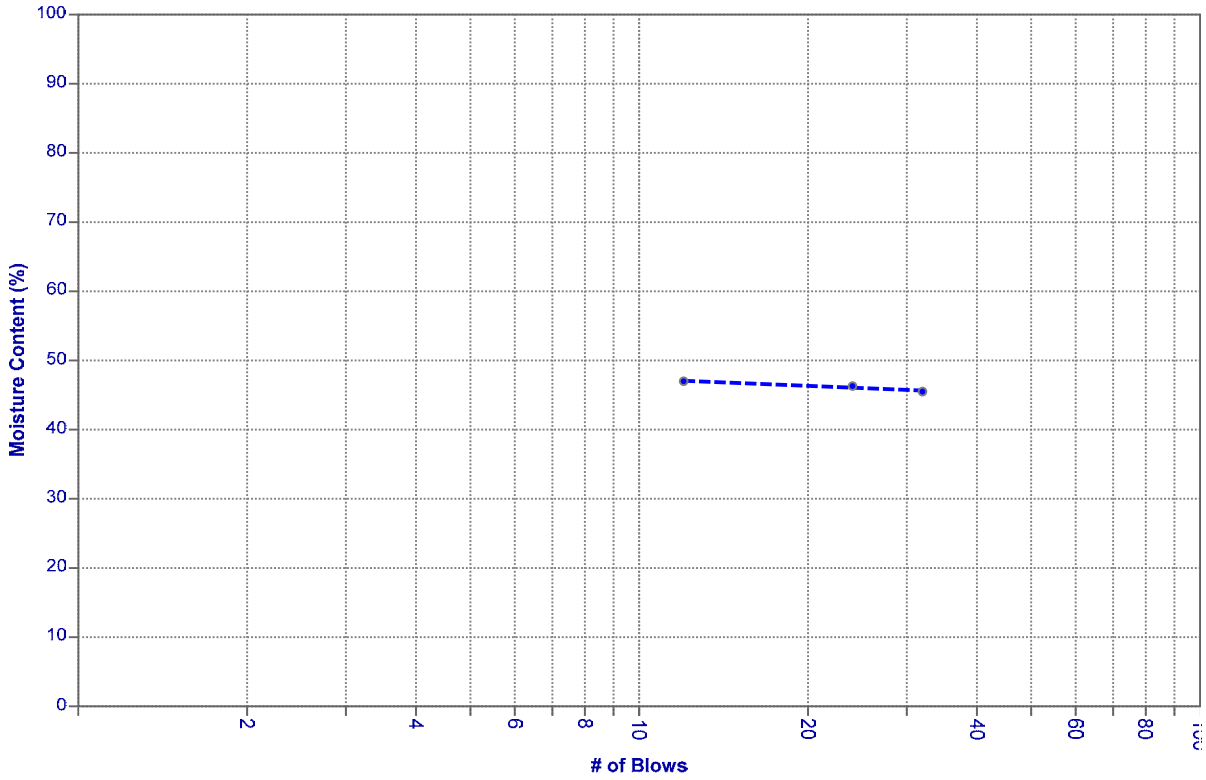
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	26.32	20.11	12	47
6.8	25.12	19.32	24	46.3
6.5	24.32	18.75	32	45.5
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.5	17.22	14.65	31.5

LL = 46 % **PL = 31.5 %** **PI=14.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-20	5.5	15.32	1.69	1.95
BH-21	4.7	17.28	1.67	1.96

Unconfined Compression Test

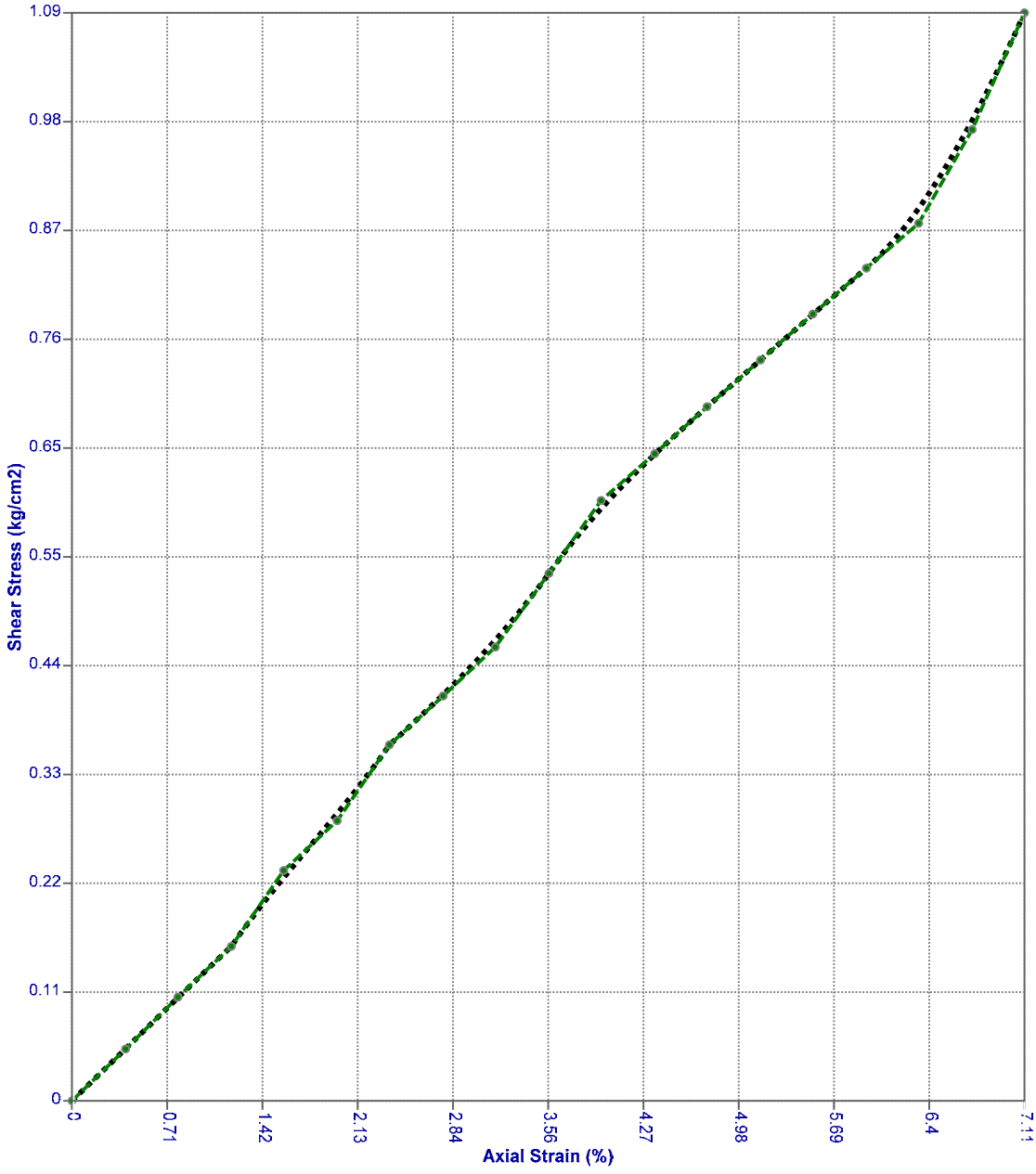
Project :	GI for Yellow BRTS Line	Borehole :	BH-21
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4.7 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
6.985	12.654	2	Moist	17.28	1.67	1.09	0.55

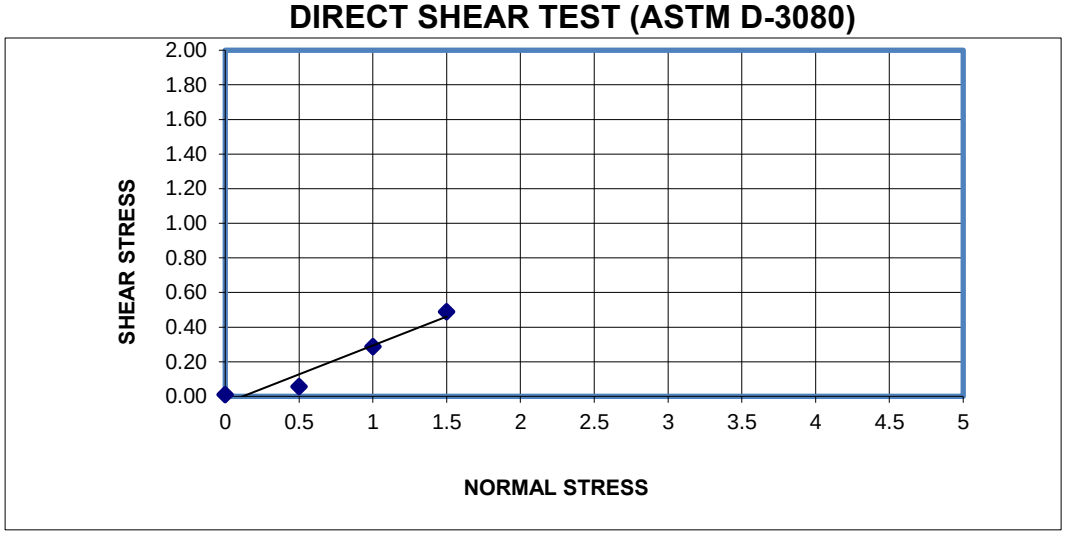


Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By :

Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-20**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**5.50 - 6.40m**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.01
0.50	0.06
1.00	0.29
1.50	0.49
Cohesion (c)	0.01
Angle of friction (Φ)	17.71



1D Consolidation Test

Project :	GI for Yellow BRTS Line	Borehole :	BH-21
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4.7 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Shelby / U4

SOIL TESTING SERVICES

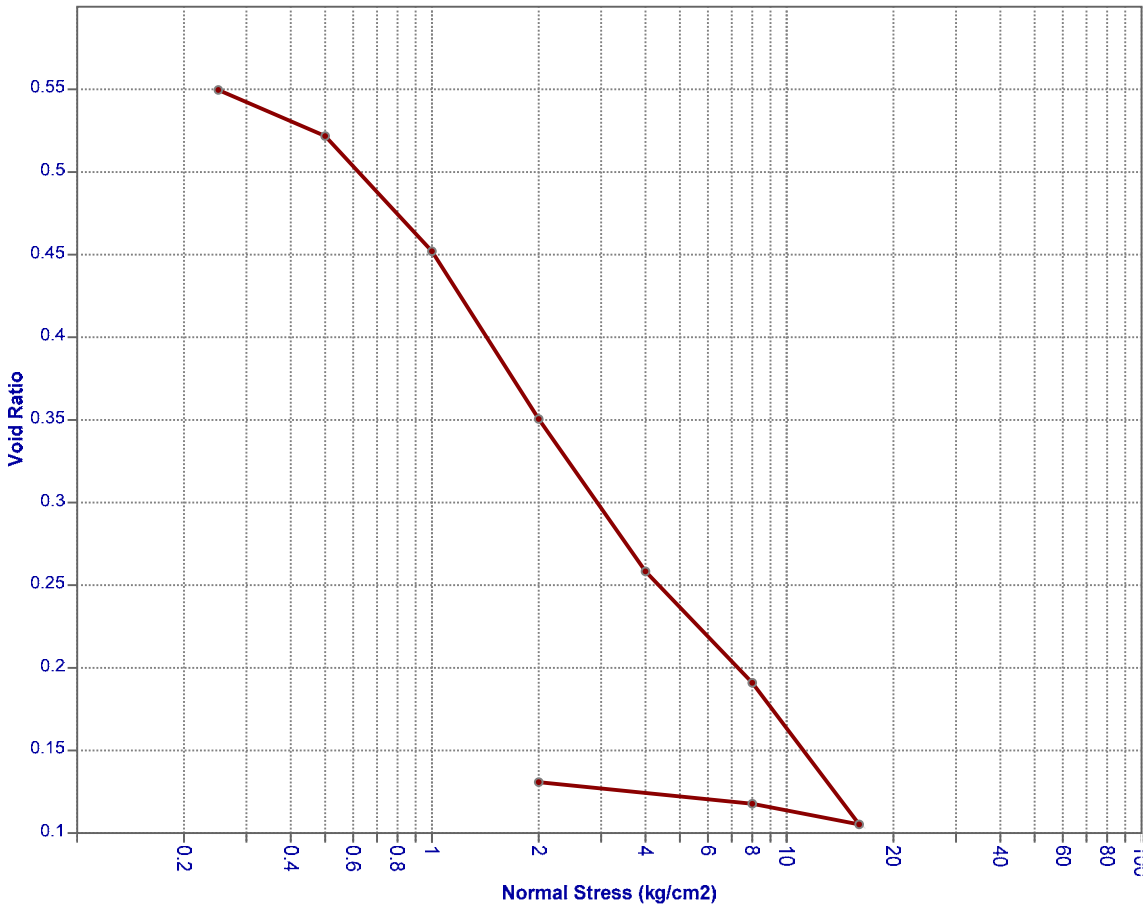
ASTM D2435

Sample Info

Diameter (cm)	Height (cm)	Dry Weight (gr)	Wet Weight Before (gr)	Wet Weight After (gr)	Void Ratio	Gs
6	2	96.3	101.3	108.6	0.55	2.64

Compression Parameters

Cc	Cs	Pre-Consolidation Pressure (kg/cm2)
0.34	0.03	1.5



Mv Values

P1 (kg/cm2)	P2 (kg/cm2)	e1	e2	Mv 1/ (kg/cm2)
0.25	0.5	0.55	0.522	7.20E-002
0.5	1	0.522	0.452	9.16E-002
1	2	0.452	0.351	6.99E-002
2	4	0.351	0.258	3.41E-002
4	8	0.258	0.191	1.34E-002
8	16	0.191	0.105	8.99E-003

Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By : HH

Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-1411, D-4972
C-1580

Borehole	Sample Depth (m)	Description	Value
BH-20	5.5	Sulphate Content (%)	0.02
BH-20	5.5	Chloride Content (%)	0.12
BH-20	5.5	Organic Matter (%)	3.65

Water Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

Soil Testing Services

ASTM D-1293, D-516
D-512, D-5907

Borehole	Sample	Sample Depth (m)	Total Salt Content (ppm)	Chloride Content (ppm)	Sulphate (ppm)	pH Values
BH-26	WS-1	2.5	2000	980	185	7.15

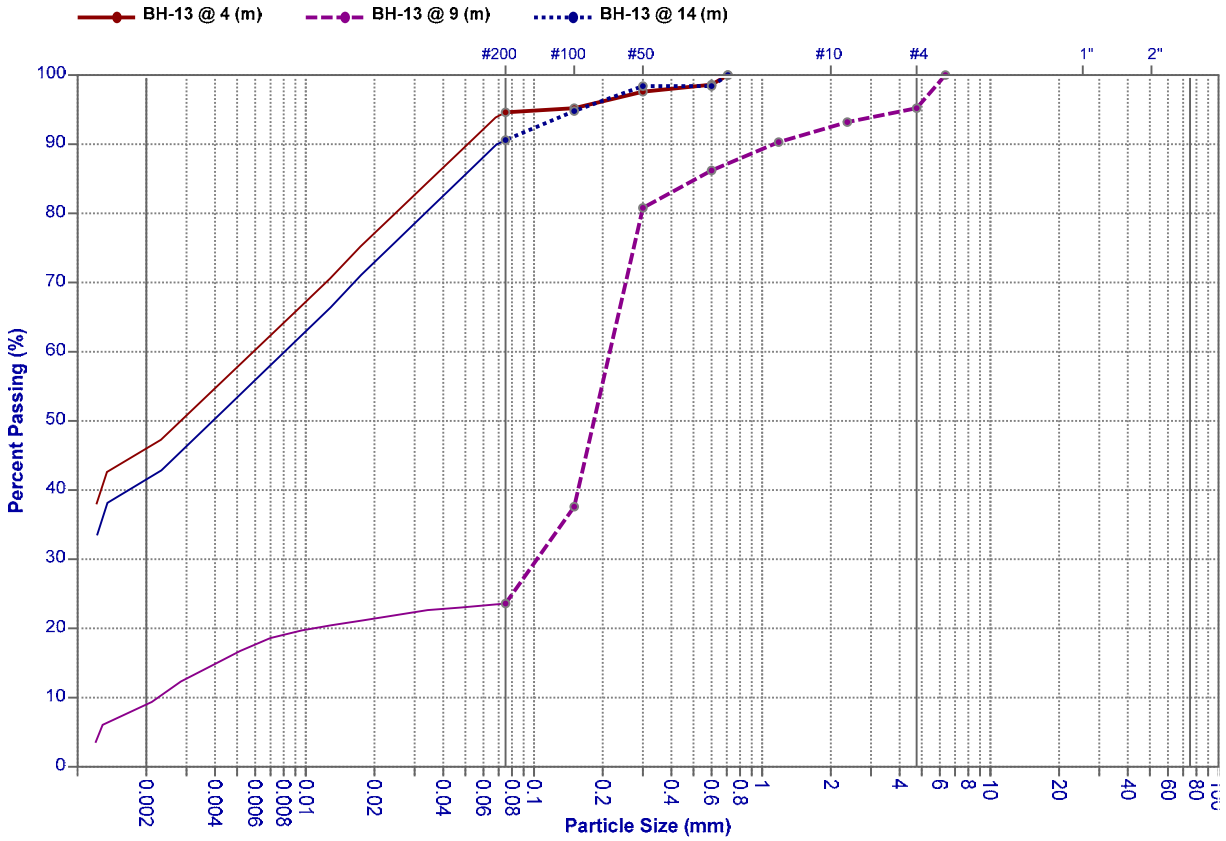
LTP-6

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
46	48.6	5.4	-	-
9	14.6	71.6	4.8	-
41.5	49.1	9.4	-	-

Classification

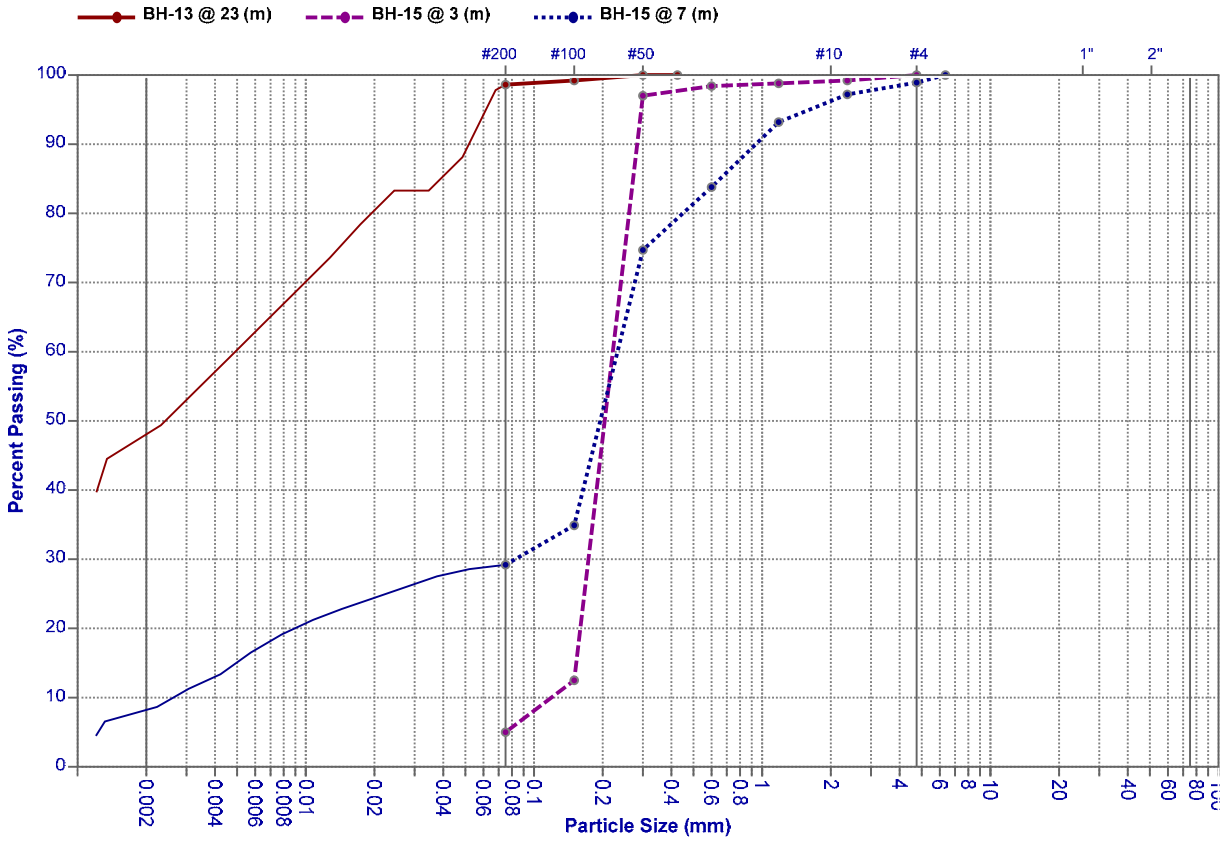
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-13	4	0.001	0.001	0.003	0.006	0.167	6	40.9	2.7	N/A	ML	A-5
BH-13	9	0.002	0.103	0.183	0.215	24.672	107.5	-	-	N/A	SM	A-2-4
BH-13	14	0.001	0.001	0.004	0.008	0.125	8	23.5	1.4	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
48.1	50.5	1.4	-	-
-	5	95	-	-
8.2	21	69.7	1.1	-

Classification

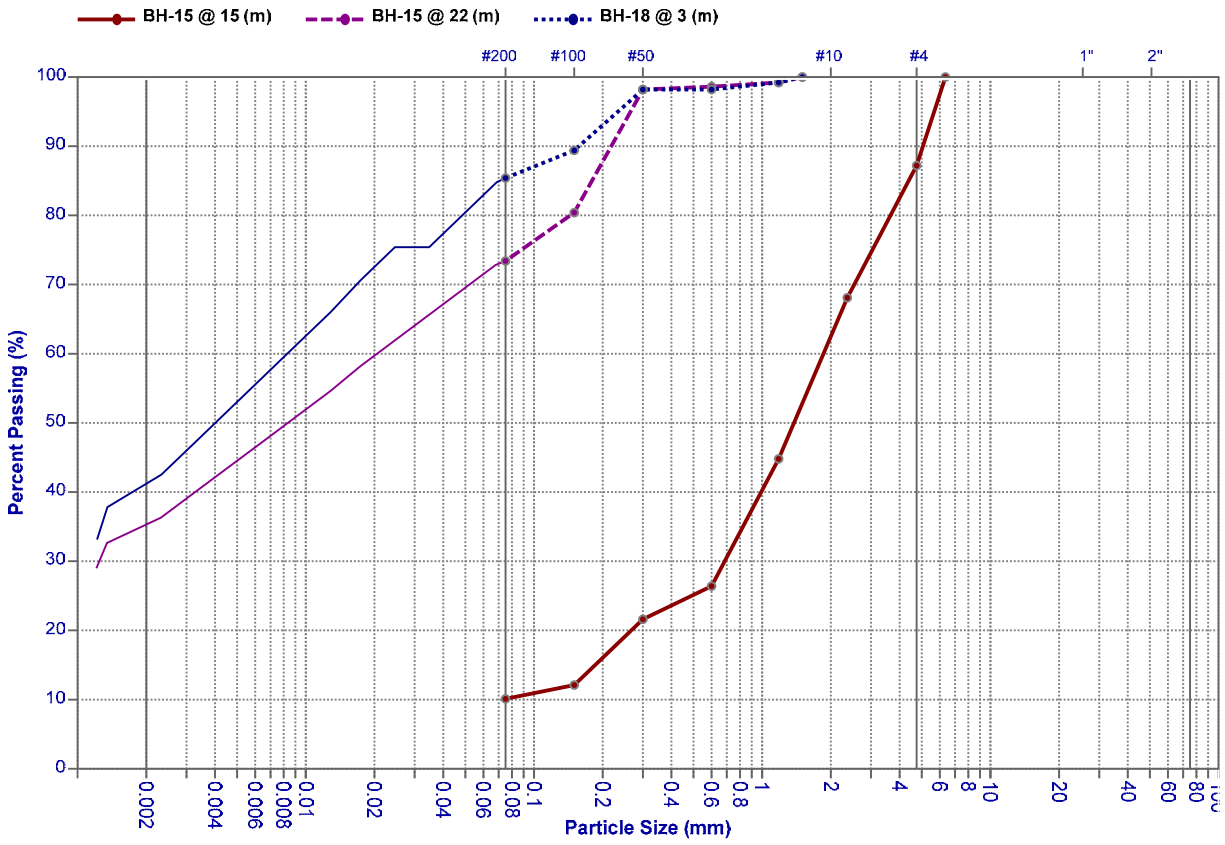
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-13	23	0.001	0.001	0.002	0.005	0.2	5	34.5	4.5	N/A	ML	A-4
BH-15	3	0.119	0.173	0.204	0.221	1.138	1.857	-	-	N/A	SP-SM	A-2-4
BH-15	7	0.003	0.083	0.195	0.232	9.898	77.333	-	-	N/A	SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	10.1	77.1	12.8	-
35.3	38.1	26.6	-	-
41.2	44.2	14.6	-	-

Classification

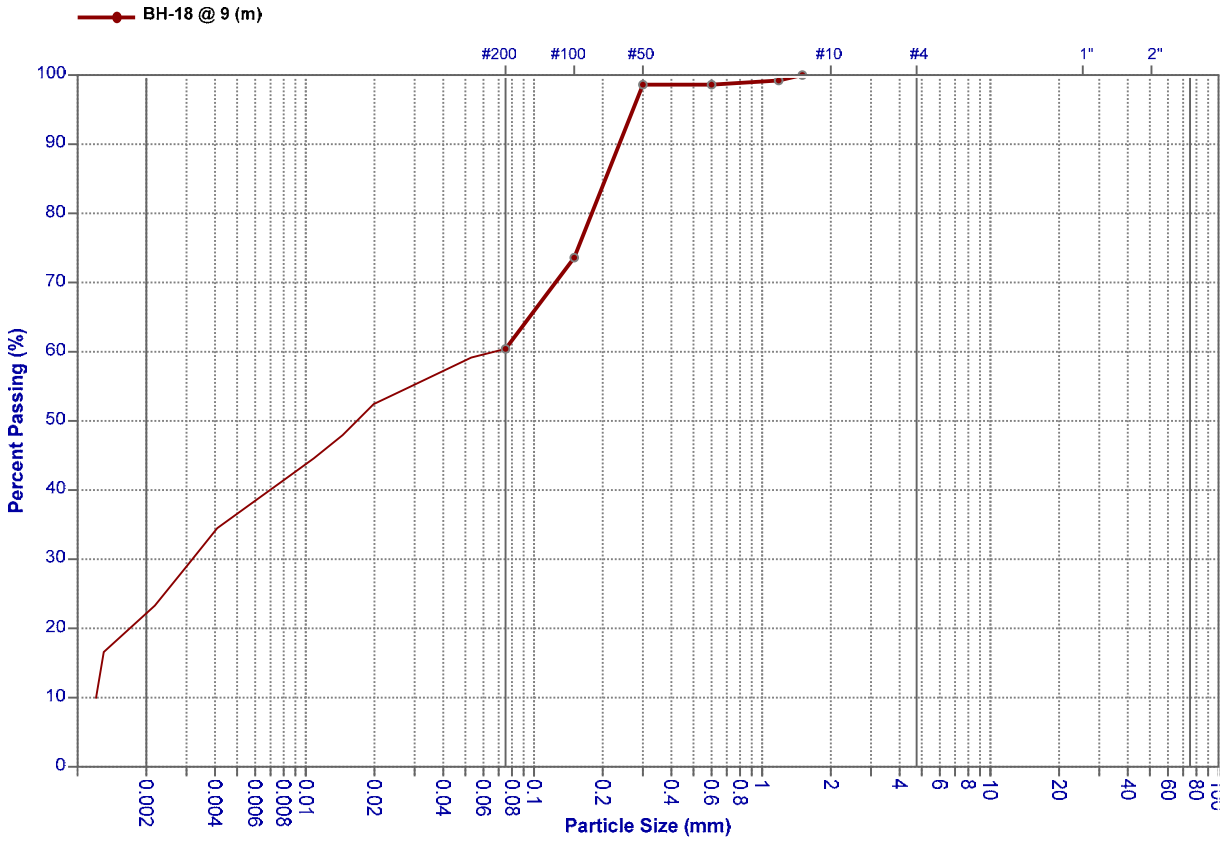
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-15	15	-	0.685	1.377	1.855	3.328	-	-	-	N/A	SP-SM	A-2-4
BH-15	22	0.001	0.001	0.008	0.021	0.048	21	22.3	0.3	N/A	ML	A-4
BH-18	3	0.001	0.001	0.004	0.008	0.125	8	39.2	4.5	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
22.2	38.2	39.6	-	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-18	9	0.001	0.003	0.017	0.067	0.134	67	-	-	N/A	ML	A-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-13
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	4 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

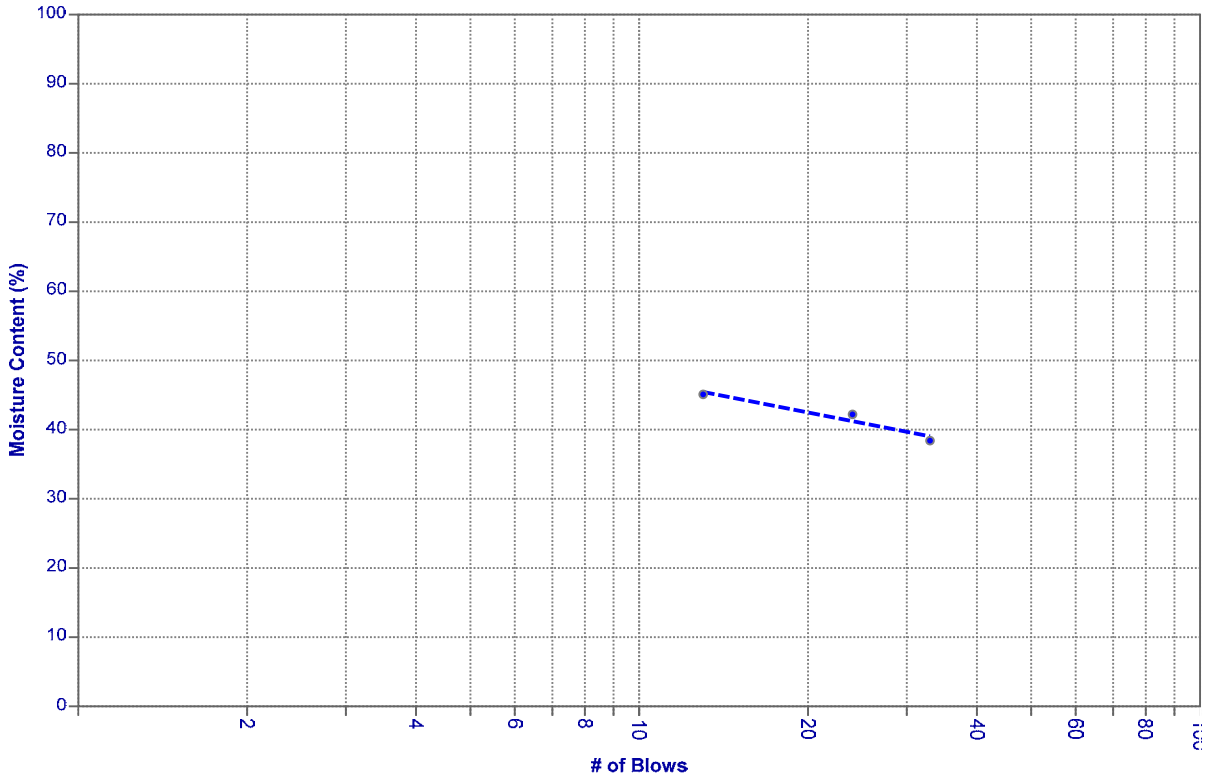
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.5	19.7	15.6	13	45.1
7.1	21.6	17.3	24	42.2
7	22.5	18.2	33	38.4
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7.2	17.7	14.8	38.2

LL = 40.9 % **PL = 38.2 %** **PI=2.7**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-13
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	14 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

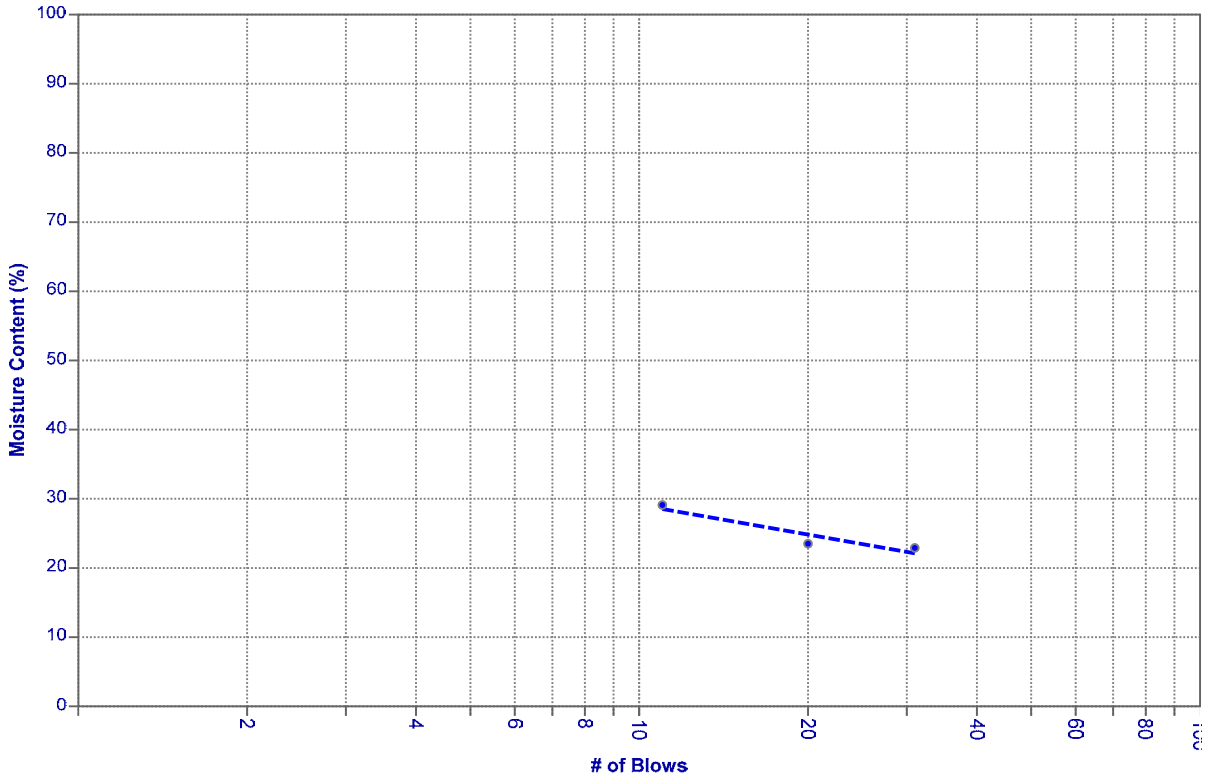
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.8	21.9	18.5	11	29.1
6.9	23.7	20.5	20	23.5
6.7	22.8	19.8	31	22.9
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.8	17.3	15.4	22.1

LL = 23.5 % **PL = 22.1 %** **PI=1.4**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-13
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	23 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

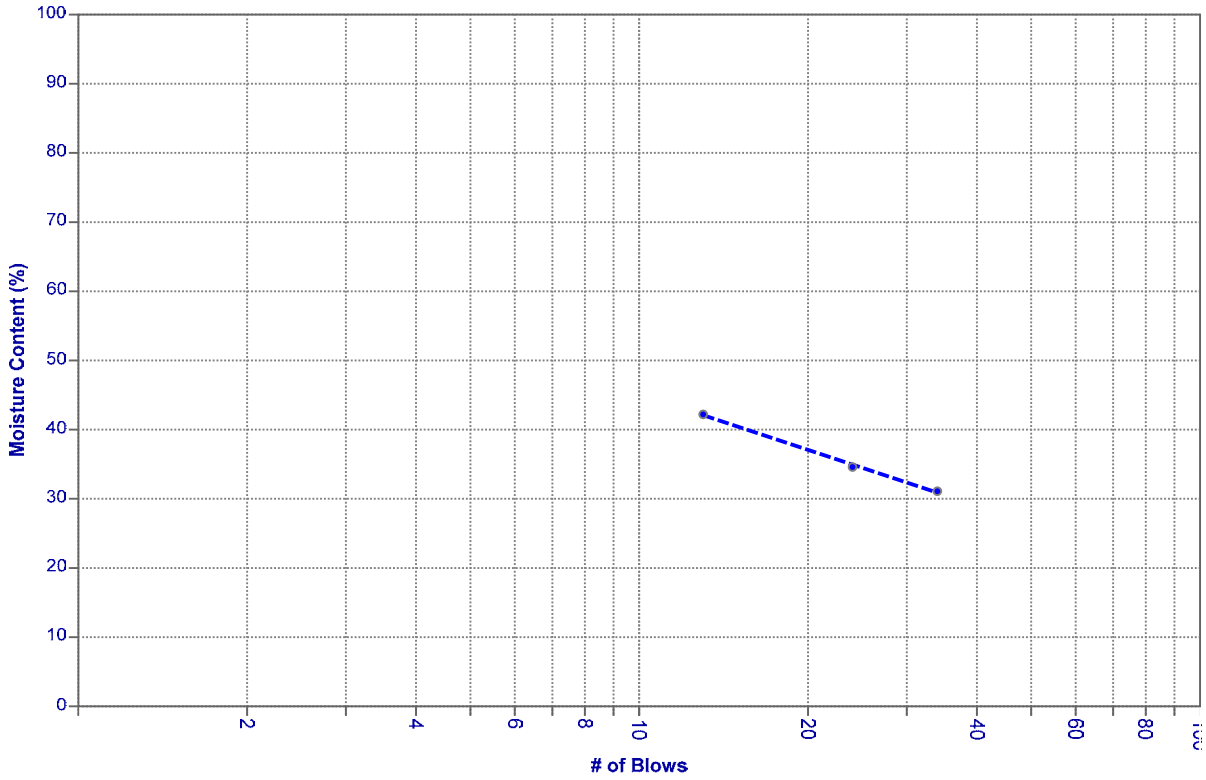
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.6	22.1	17.5	13	42.2
6.9	21.3	17.6	24	34.6
6.7	22.7	18.9	34	31.1
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7.2	17.6	15.2	30

LL = 34.5 % **PL = 30 %** **PI=4.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-15
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	22 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

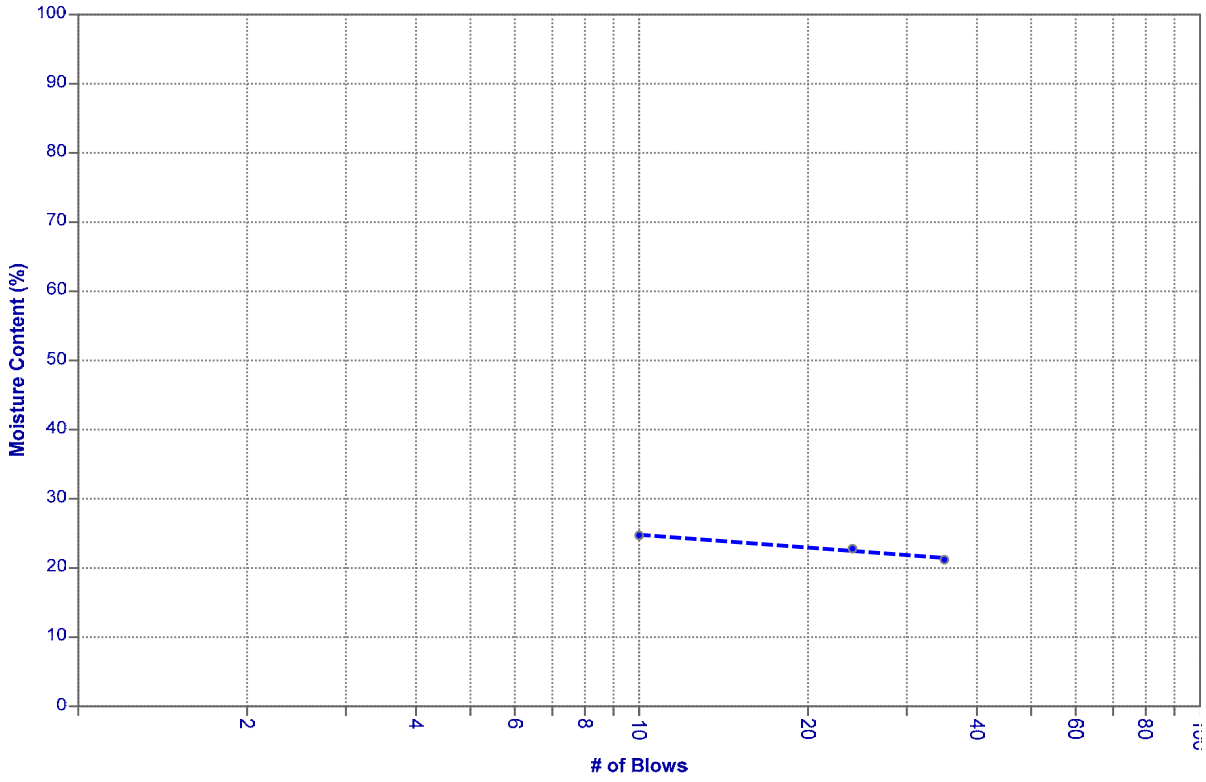
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7.1	27.3	23.3	10	24.7
6.7	18	15.9	24	22.8
6.8	21.1	18.6	35	21.2
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.7	17.8	15.8	22

LL = 22.3 % **PL = 22 %** **PI=0.3**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-18
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	3 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

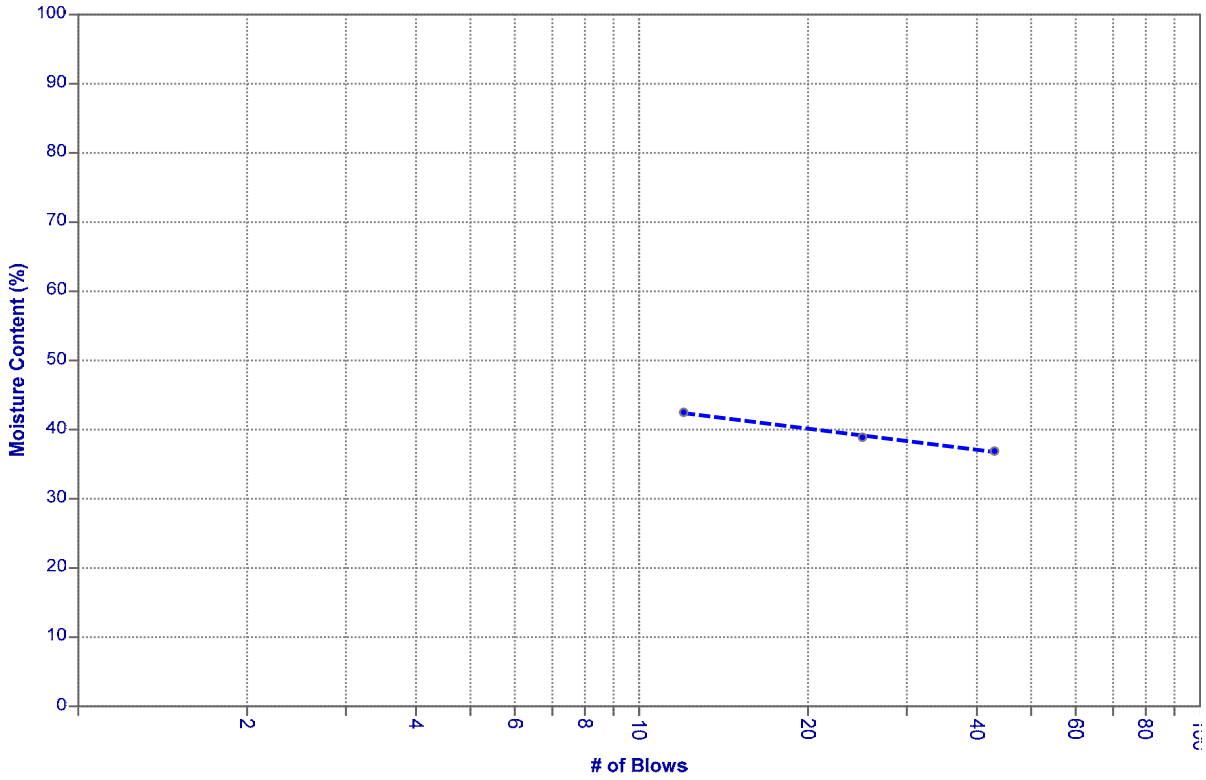
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	25	19.6	12	42.5
6.9	29.4	23.1	25	38.9
6.9	26.2	21	43	36.9
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7.1	17.2	14.6	34.7

LL = 39.2 % **PL = 34.7 %** **PI=4.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-13	9	16.67	1.71	2
BH-13	24.7	5.54	2.18	2.3
BH-15	7	12.27	1.75	1.96
BH-15	25.3	10.79	2.08	2.3
BH-15	28.33	8.94	1.95	2.12

Unconfined Compression Test

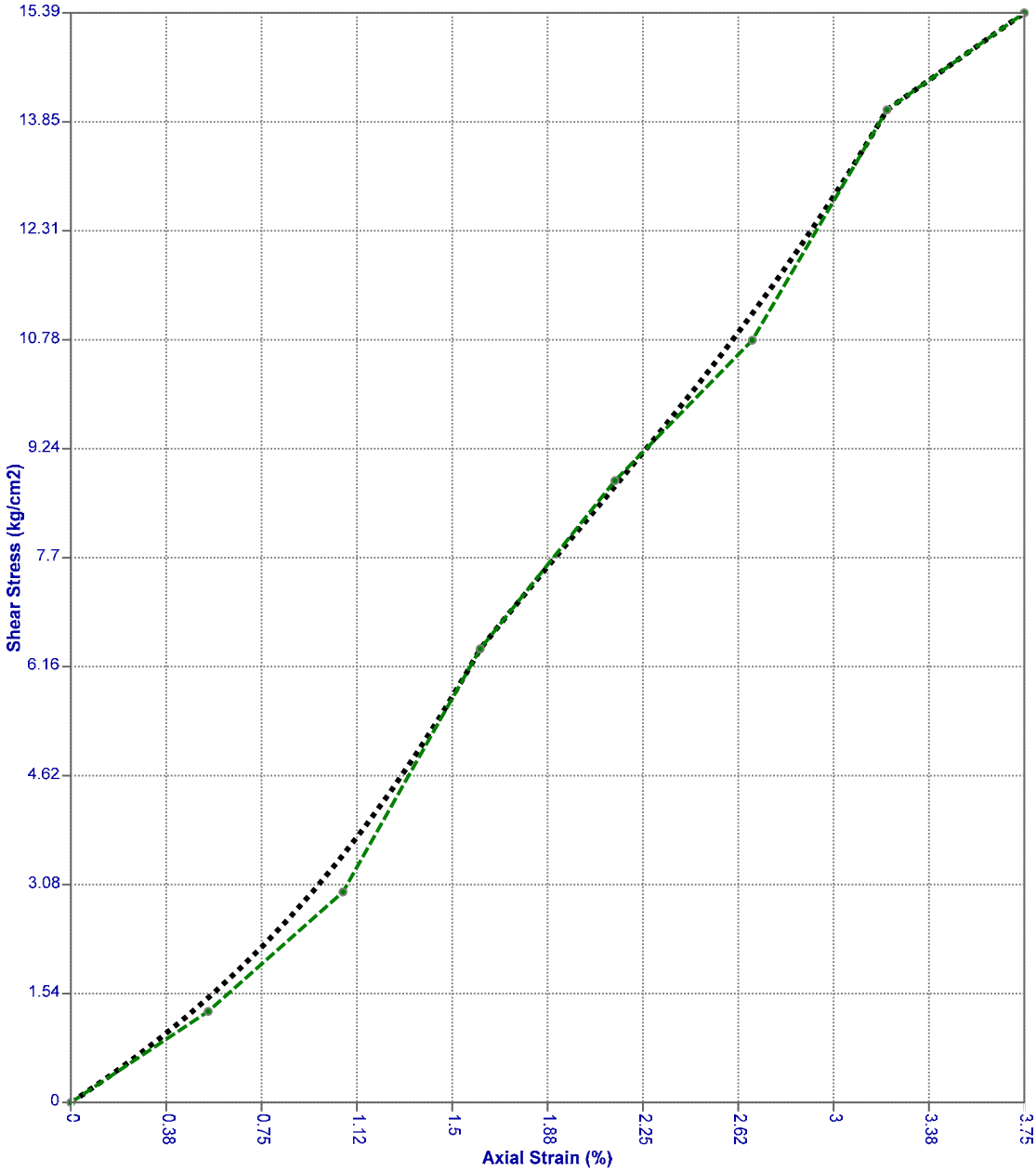
Project :	GI for Yellow BRTS Line	Borehole :	BH-13
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	24.7 (m)
Job No.:	K19-1092-101	Rock Name :	Mudstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	9.337	2	Moist	5.54	2.18	15.39	7.7



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

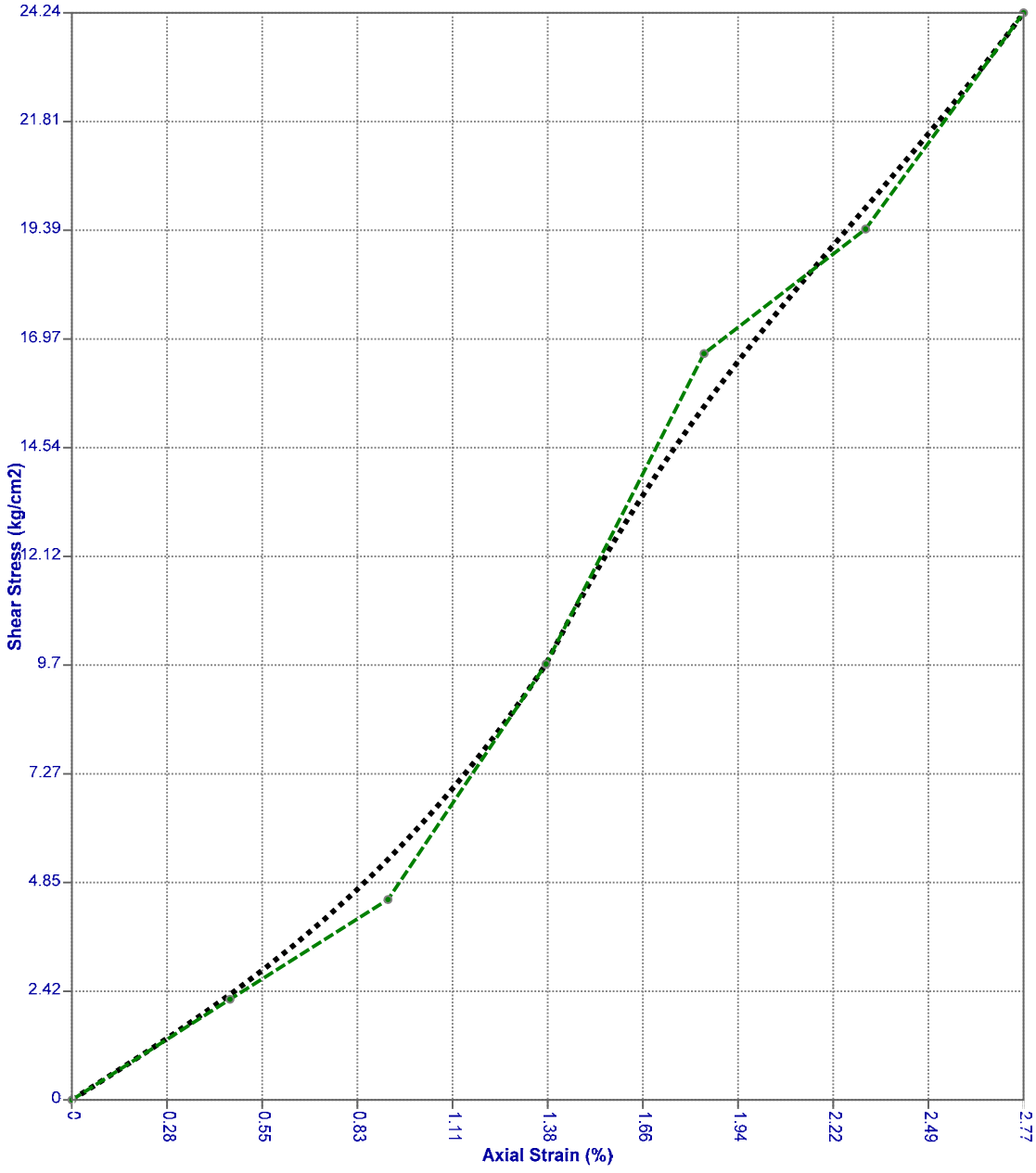
Project :	GI for Yellow BRTS Line	Borehole :	BH-15
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	25.3 (m)
Job No.:	K19-1092-101	Rock Name :	Mudstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	10.843	2	Moist	10.79	2.08	24.24	12.12



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

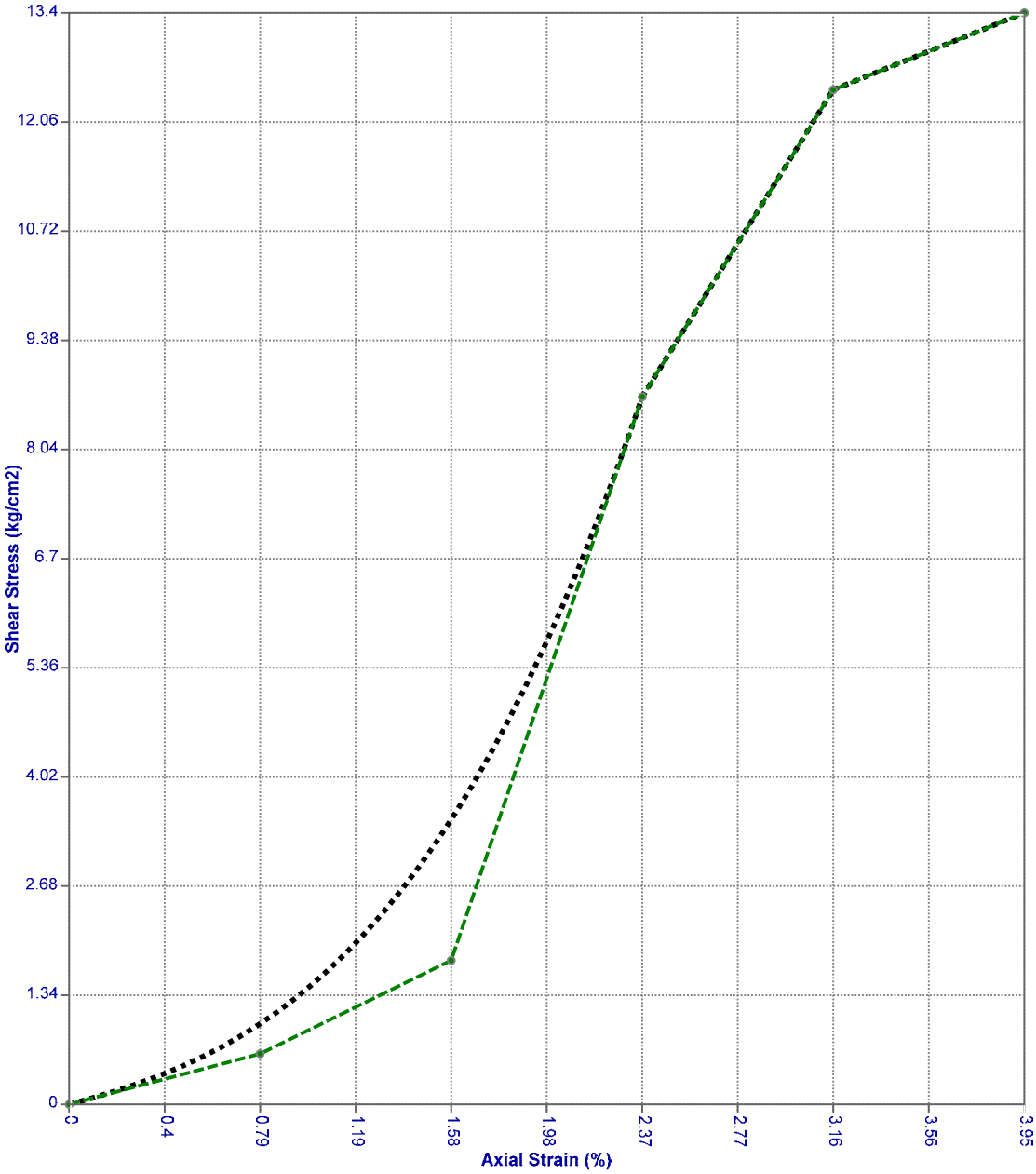
Project :	GI for Yellow BRTS Line	Borehole :	BH-15
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	28.33 (m)
Job No.:	K19-1092-101	Rock Name :	Mudstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	6.325	2	Moist	8.94	1.95	13.4	6.7

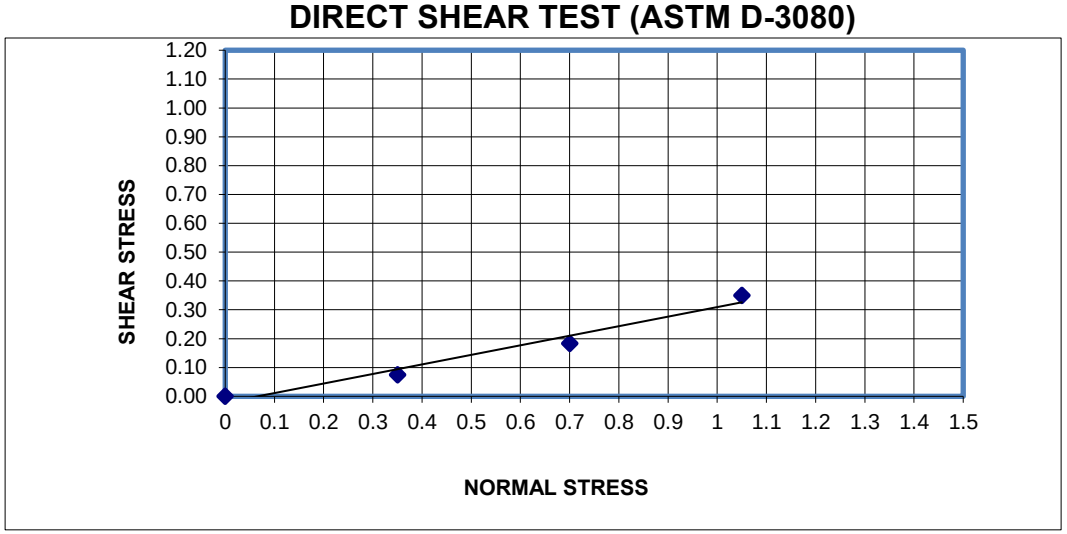


Unified Description :
AASHTO Description :

Tested By :

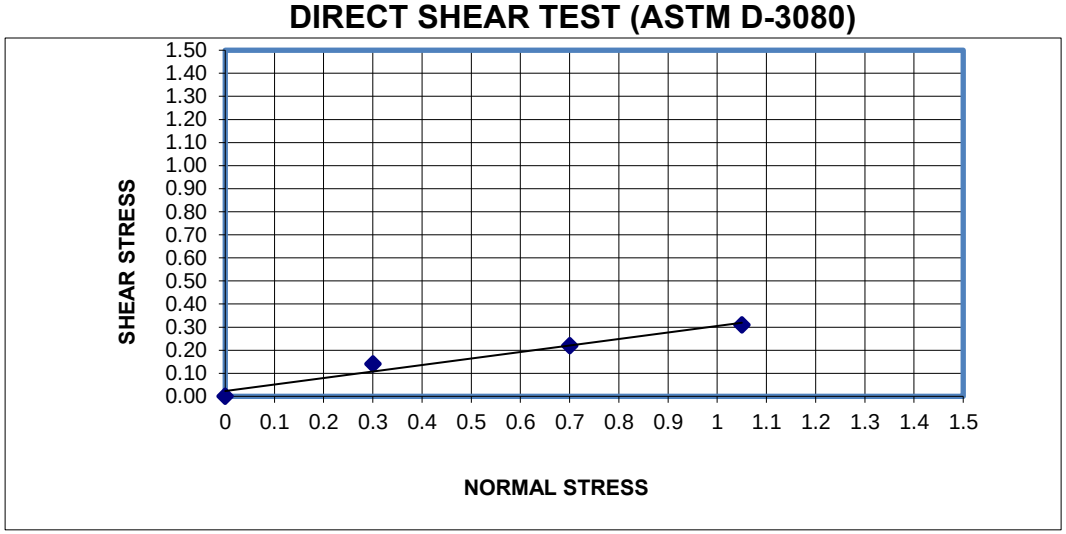
Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-13**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**9.00 - 9.90m**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.35	0.07
0.70	0.18
1.05	0.35
Cohesion (c)	0.00
Angle of friction (Φ)	18.44



Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-15**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**7.00 - 7.45m**
Job No.	:	**K19-1092-101**	**Classification**	:	**UDS - 1**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.35	0.14
0.70	0.22
1.05	0.31
Cohesion (c)	0.00
Angle of friction (Φ)	16.45



Chemical Test Results

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-1293, D-516
D-512, D-5907

Borehole	Sample Depth (m)	Description	Value
BH-15	7	Sulphate Content (%)	0.01
BH-15	7	Chloride Content (%)	0.15
BH-15	7	Organic Matter (%)	2.32

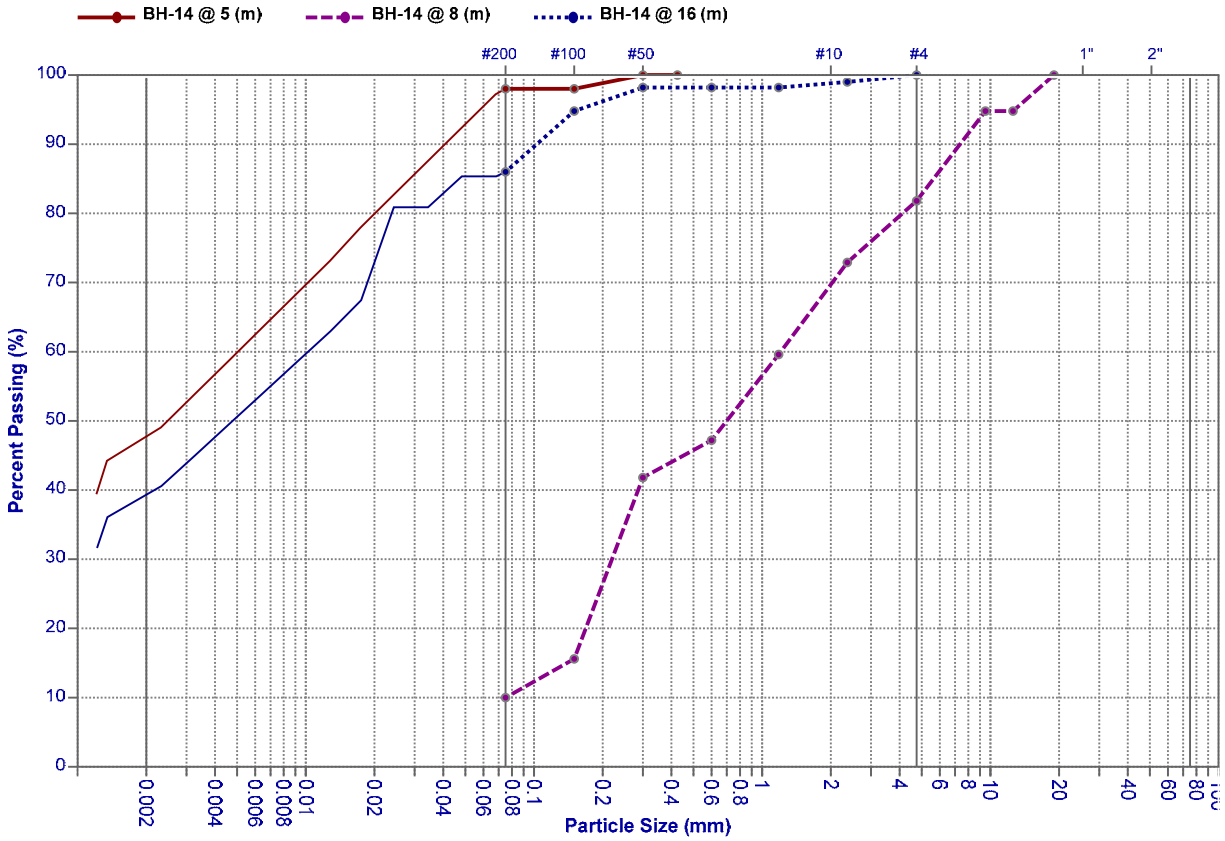
LTP-7

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
47.7	50.3	2	-	-
-	10	71.8	18.2	-
39.3	46.7	14	-	-

Classification

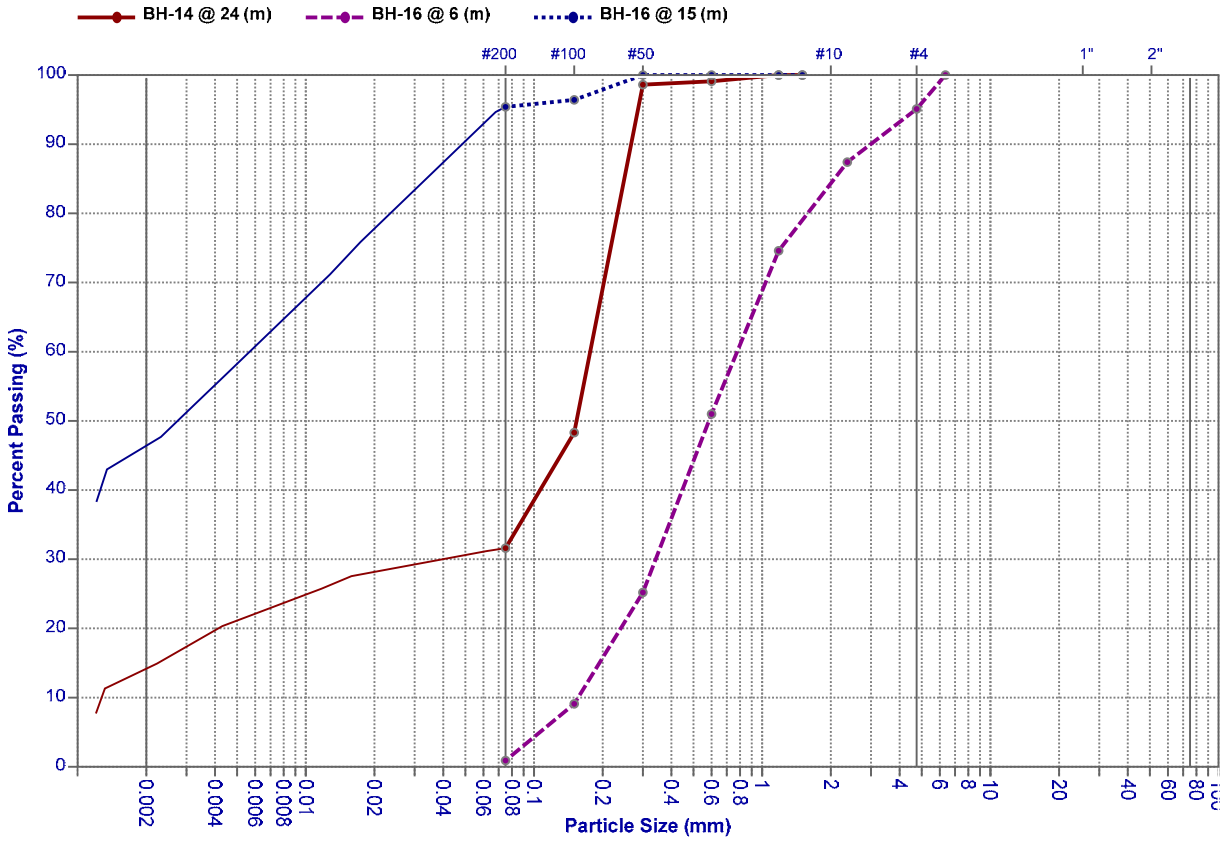
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-14	5	0.001	0.001	0.002	0.005	0.2	5	26	1	N/A	ML	A-4
BH-14	8	0.076	0.22	0.699	1.205	0.528	15.855	-	-	N/A	SP-SM	A-1-b
BH-14	16	0.001	0.001	0.005	0.01	0.1	10	23.5	3.5	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
14.2	17.4	68.4	-	-
-	0.9	94.2	4.9	-
46.4	49	4.6	-	-

Classification

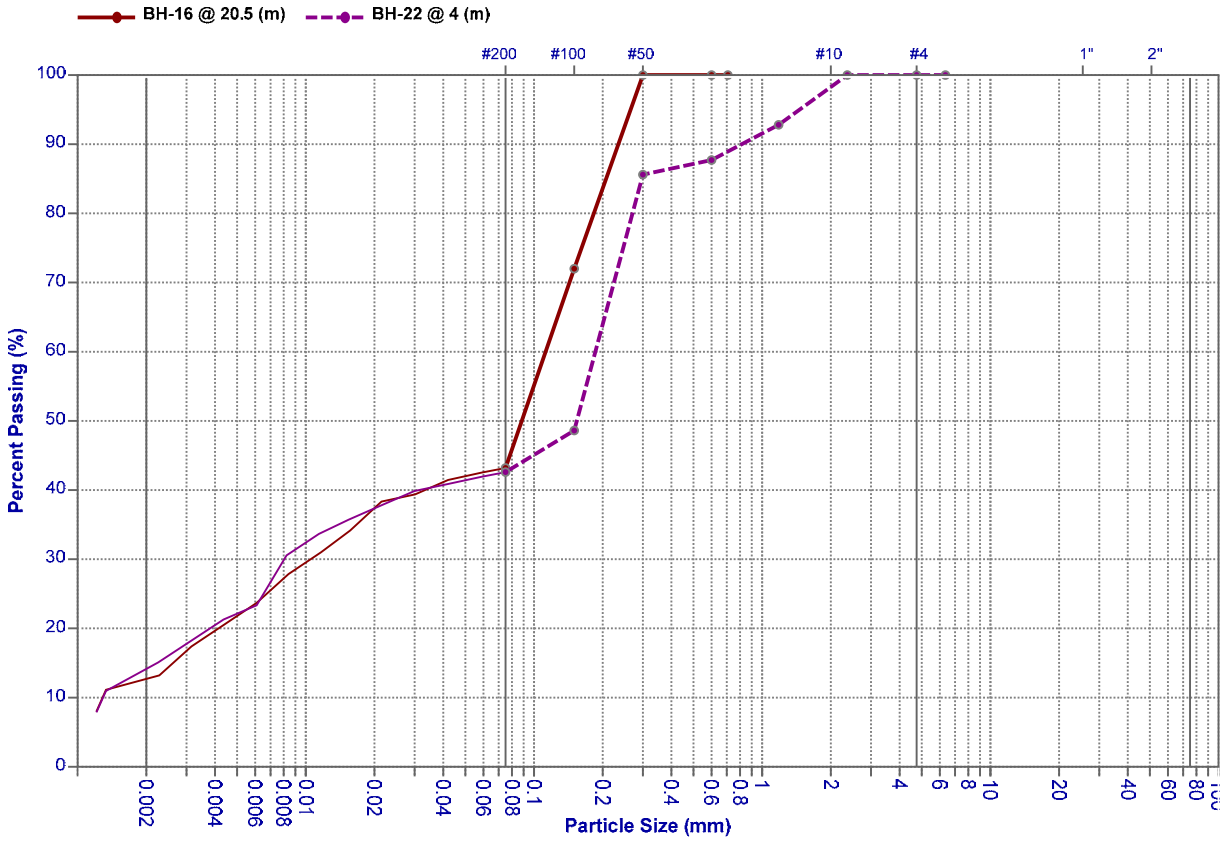
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-14	24	0.001	0.04	0.154	0.176	9.091	176	-	-	N/A	SM	A-2-4
BH-16	6	0.156	0.341	0.584	0.777	0.959	4.981	-	-	N/A	SP	A-3
BH-16	15	0.001	0.001	0.003	0.006	0.167	6	28.3	5.7	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
12.7	30.5	56.8	-	-
14.2	28.4	57.4	-	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-16	20.5	0.001	0.01	0.088	0.112	0.893	112	-	-	N/A	SM	A-4
BH-22	4	0.001	0.008	0.154	0.186	0.344	186	-	-	N/A	SM	A-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-14
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	5 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

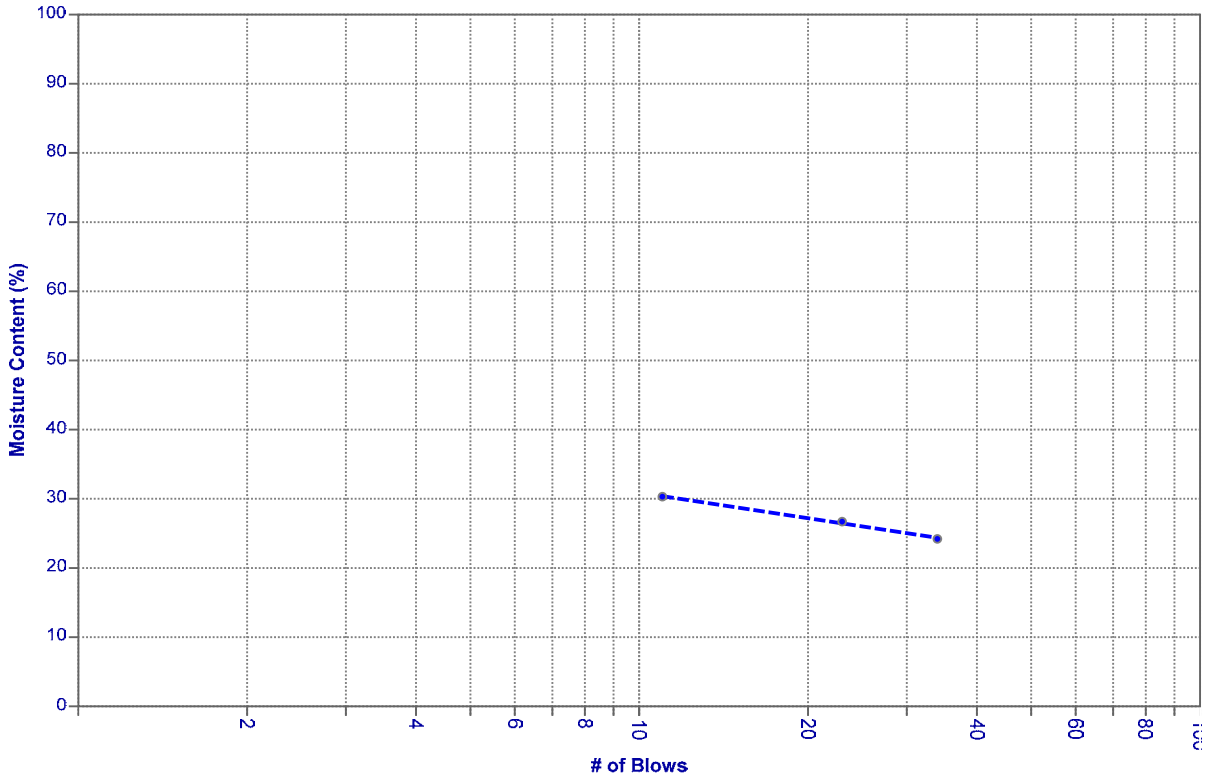
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.6	19.5	16.5	11	30.3
6.9	17.8	15.5	23	26.7
7	21.9	19	34	24.2
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	16.4	14.5	25

LL = 26 % **PL = 25 %** **PI=1**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-14
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	16 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

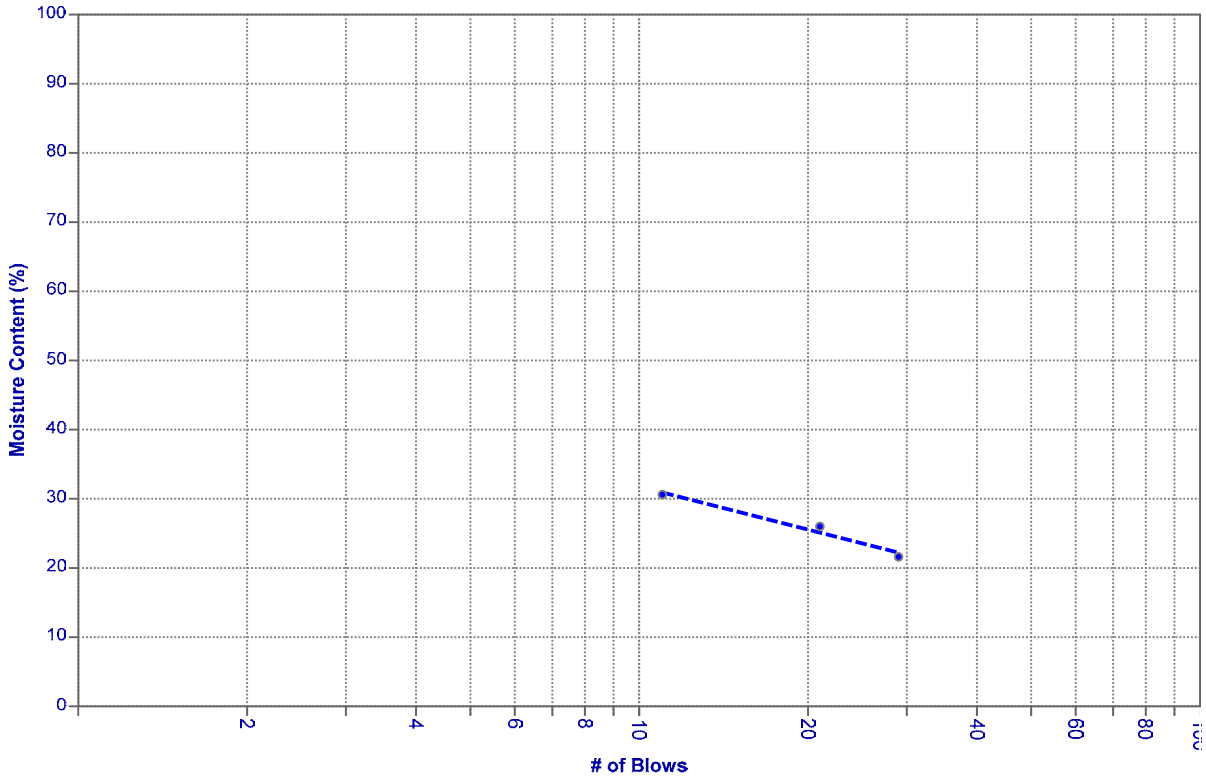
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
7.1	22.9	19.2	11	30.6
7	20.1	17.4	21	26
6.9	25.4	22.12	29	21.6
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
7.1	17.3	15.6	20

LL = 23.5 % **PL = 20 %** **PI=3.5**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	BH-16
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	15 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	SPT Split Spoon

SOIL TESTING SERVICES

ASTM D-4318

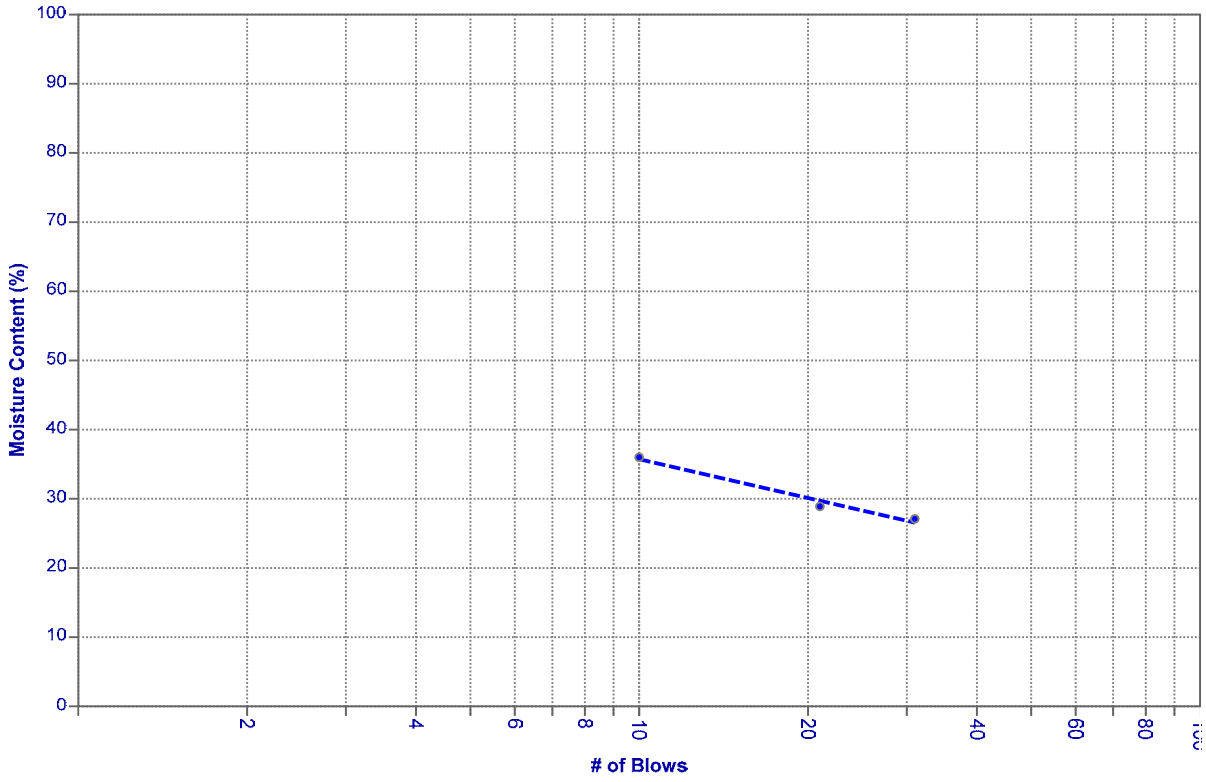
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.6	22.1	18	10	36
7.2	24.6	20.7	21	28.9
6.8	21.8	18.6	31	27.1
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.9	17.2	15.3	22.6

LL = 28.3 % **PL = 22.6 %** **PI=5.7**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

Density & Moisture Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM D-7263, D-2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH-14	8	11.45	1.71	1.91
BH-14	27.44	5.24	1.86	1.96
BH-16	6	13.62	1.73	1.97
BH-16	24.44	6.25	1.87	1.99
BH-16	31.27	10.18	1.78	1.96
BH-22	8.31	1.32	2.48	2.51

Unconfined Compression Test

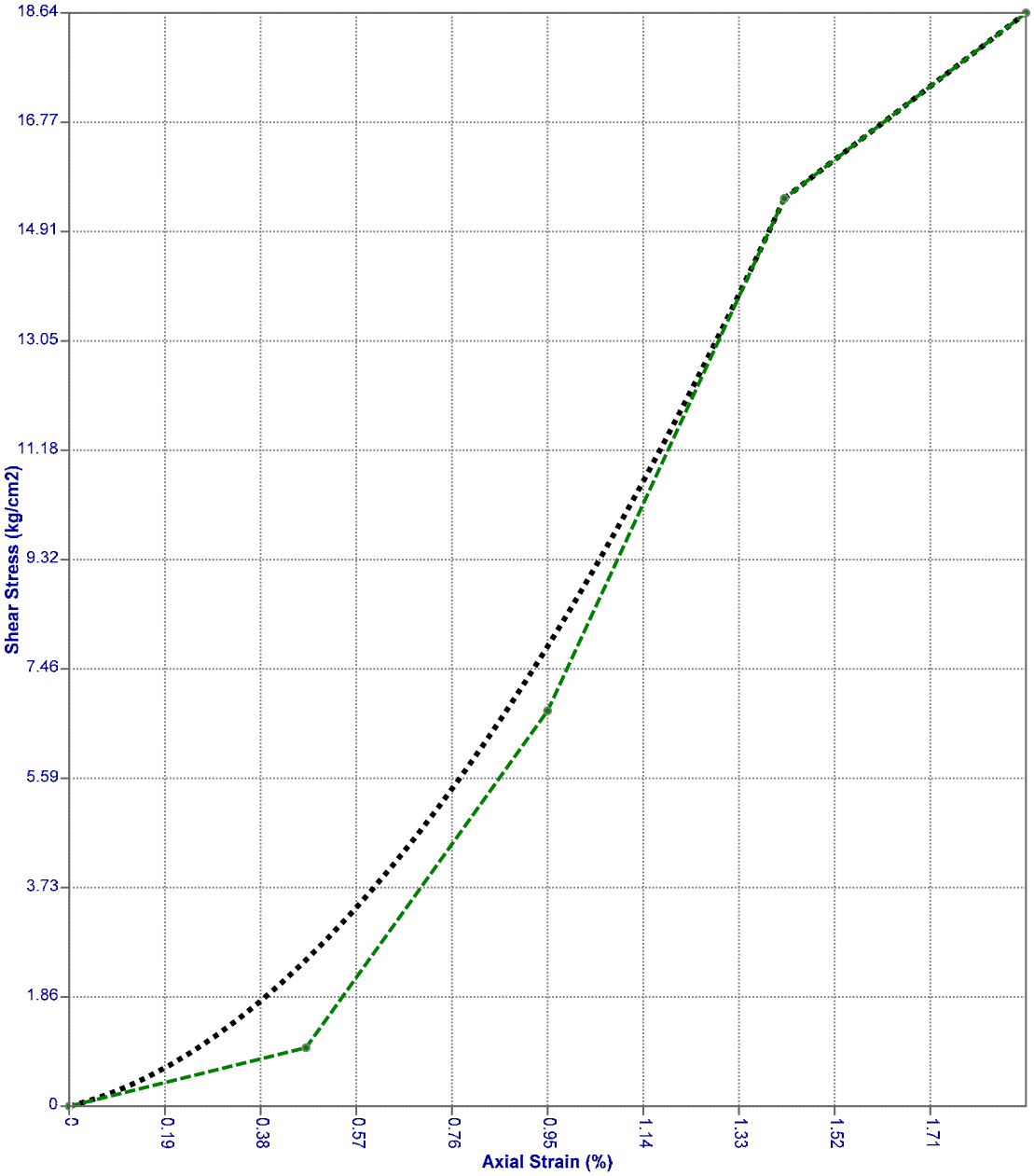
Project :	GI for Yellow BRTS Line	Borehole :	BH-14
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	27.44 (m)
Job No.:	K19-1092-101	Rock Name :	Sandstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	10.541	2	Moist	5.24	1.86	18.64	9.32



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

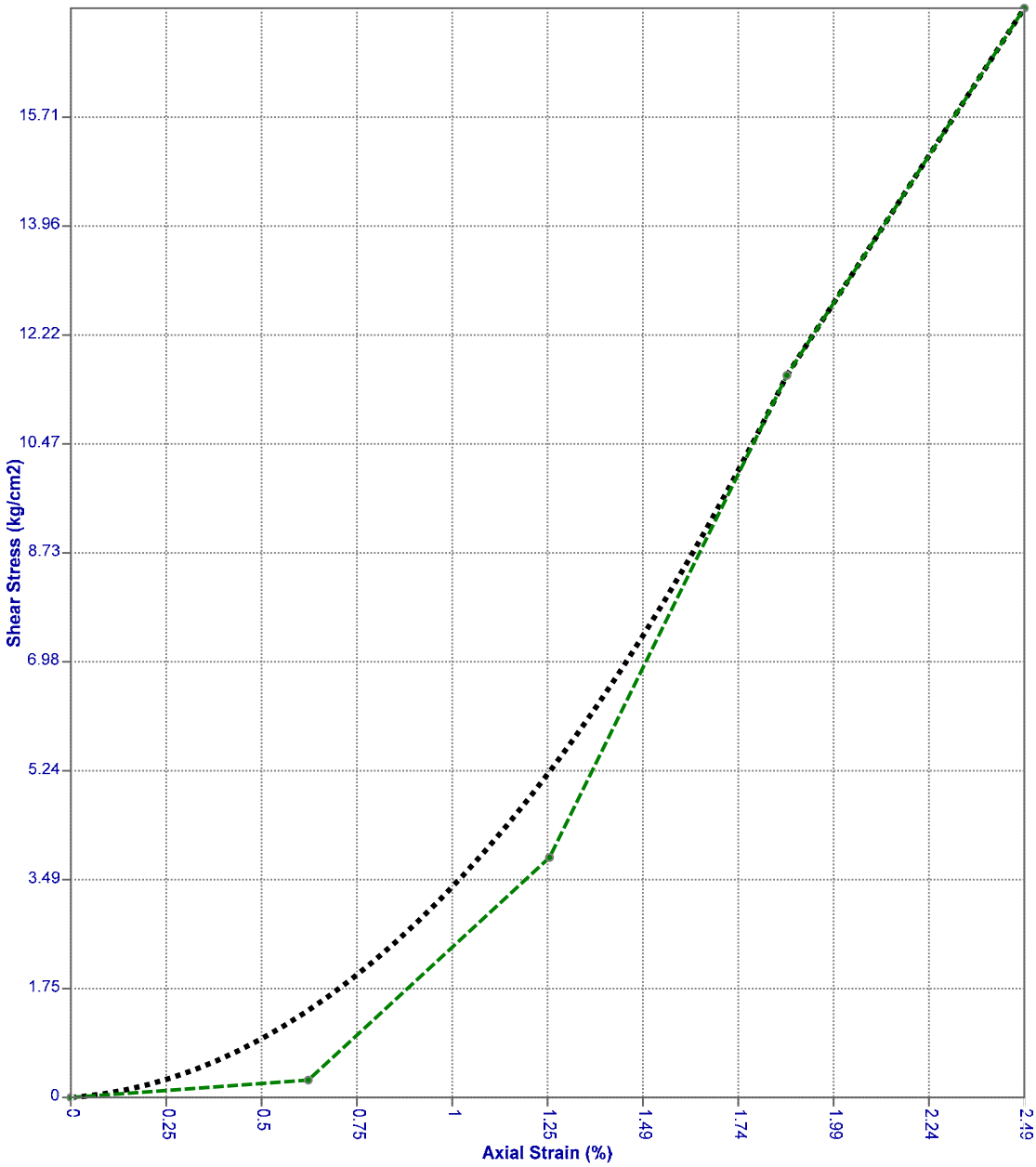
Project :	GI for Yellow BRTS Line	Borehole :	BH-16
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	24.44 (m)
Job No.:	K19-1092-101	Rock Name :	Sandstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
6.023	8.032	2	Moist	6.25	1.87	17.45	8.72



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

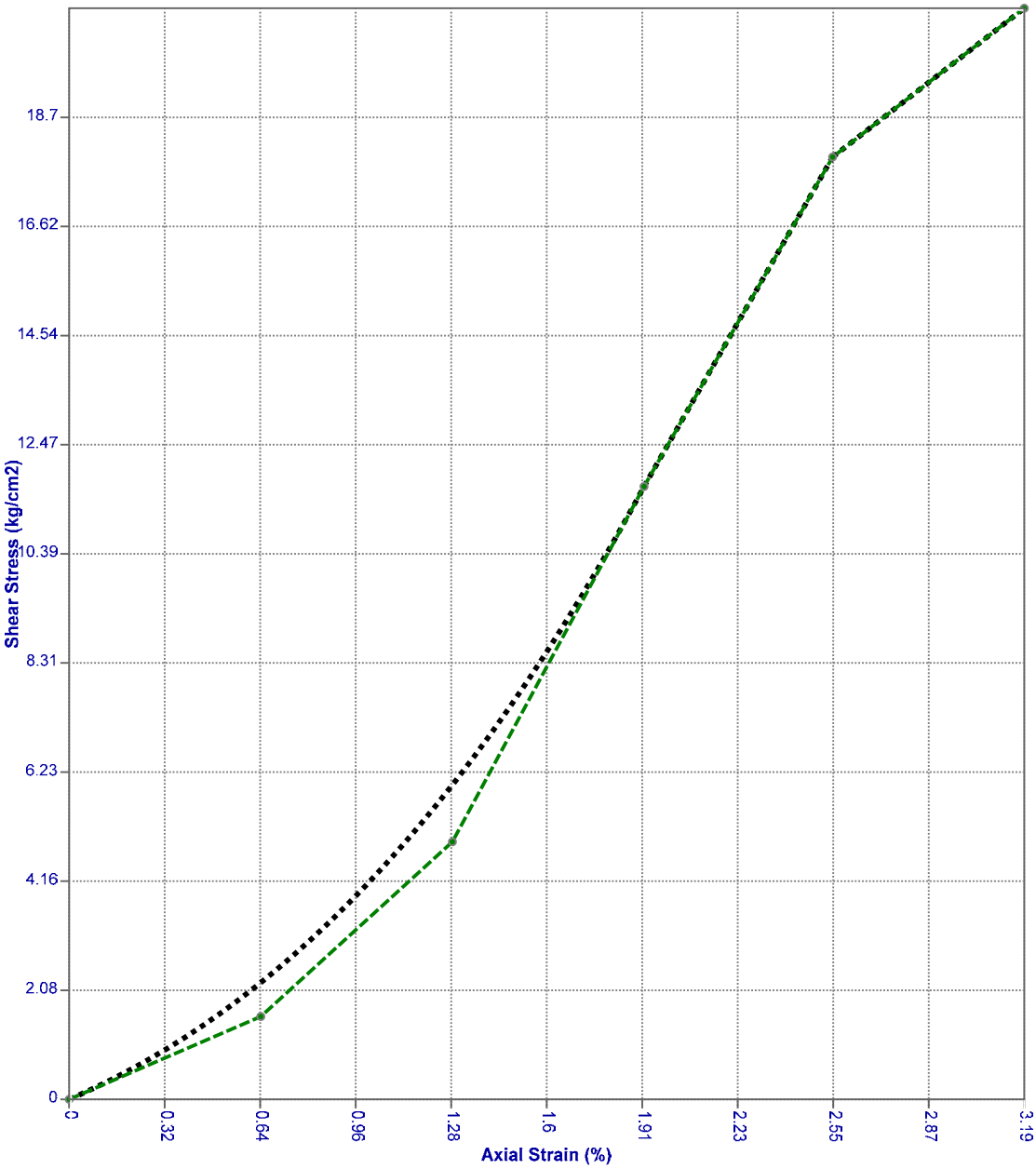
Project :	GI for Yellow BRTS Line	Borehole :	BH-16
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	31.27 (m)
Job No.:	K19-1092-101	Rock Name :	Sandstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.522	7.831	2	Moist	10.18	1.78	20.78	10.39



Unified Description :
AASHTO Description :

Tested By :

Unconfined Compression Test

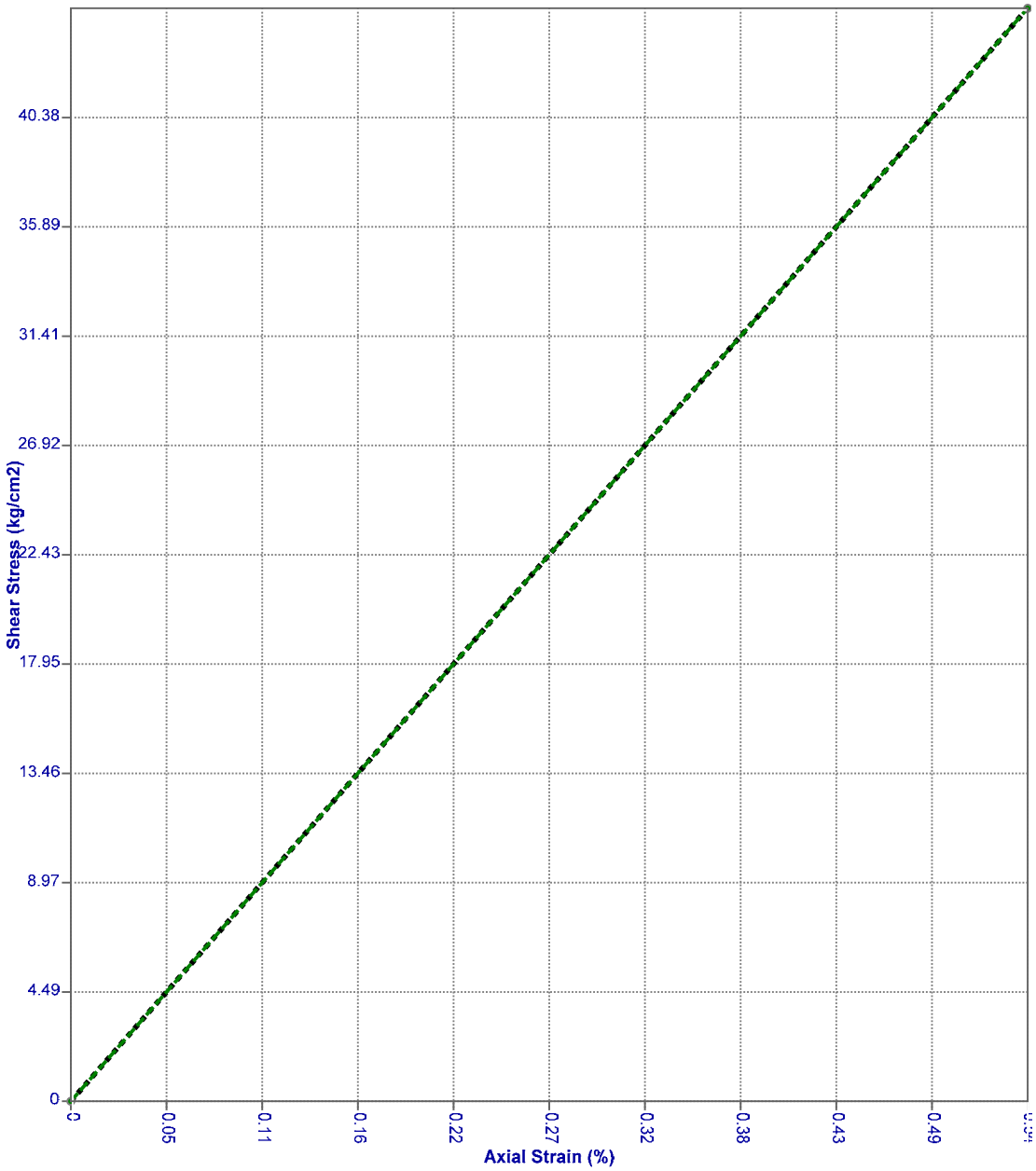
Project :	GI for Yellow BRTS Line	Borehole :	BH-22
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	8.31 (m)
Job No.:	K19-1092-101	Rock Name :	Mudstone
Location :	Korangi, Karachi	Sample Type :	Undisturbed

SOIL TESTING SERVICES

ASTM D-2938

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Compression qu (kg/cm2)	Cu (kg/cm2)
5.02	9.237	2	Moist	1.32	2.48	44.87	22.44

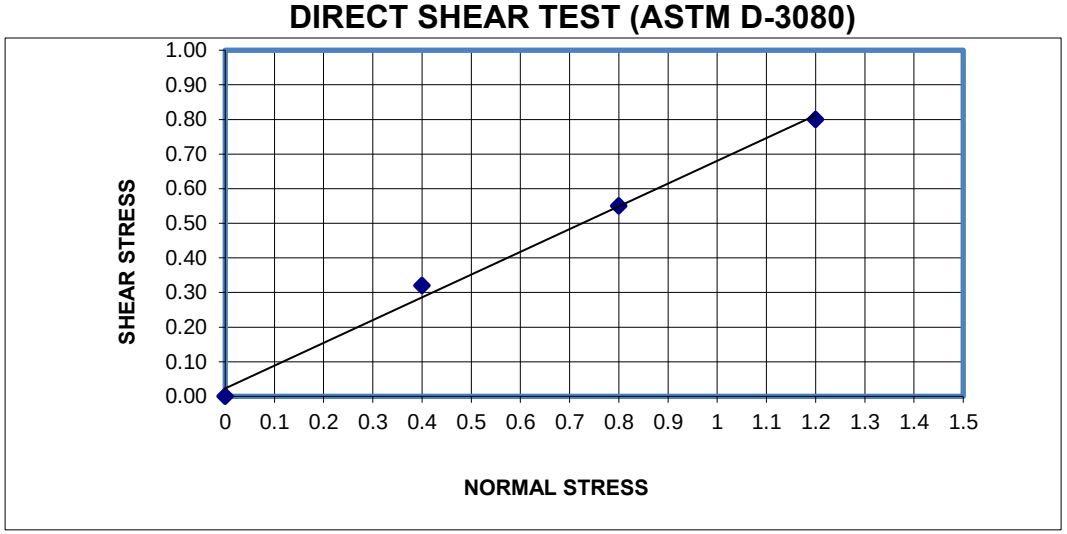


Unified Description :
AASHTO Description :

Tested By :

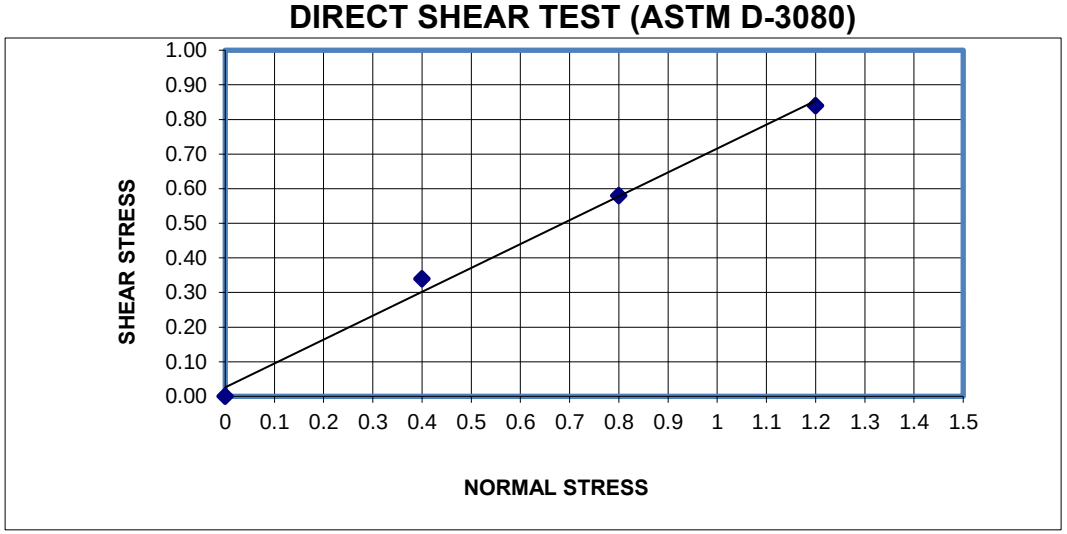
Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-14**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**8.0 (m)**
Job No.	:	**K19-1092-101**	**Classification**	:	**SP-SM**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.40	0.32
0.80	0.55
1.20	0.80
Cohesion (c)	0.00
Angle of friction (Φ)	33.69



Project	:	**GI for Yellow BRTS Line**	**Sample Marking**	:	**BH-16**
Client	:	**Nespak (Pvt.) Ltd.**	**Sample Depth**	:	**6.0 (m)**
Job No.	:	**K19-1092-101**	**Classification**	:	**SP**
Location	:	**Korangi, Karachi**	**Sample Type**	:	**Undisturbed**

NORMAL STRESS (kg/cm^2)	SHEAR STRESS (kg/cm^2)
0.00	0.00
0.40	0.34
0.80	0.58
1.20	0.84
Cohesion (c)	0.00
Angle of friction (Φ)	34.99



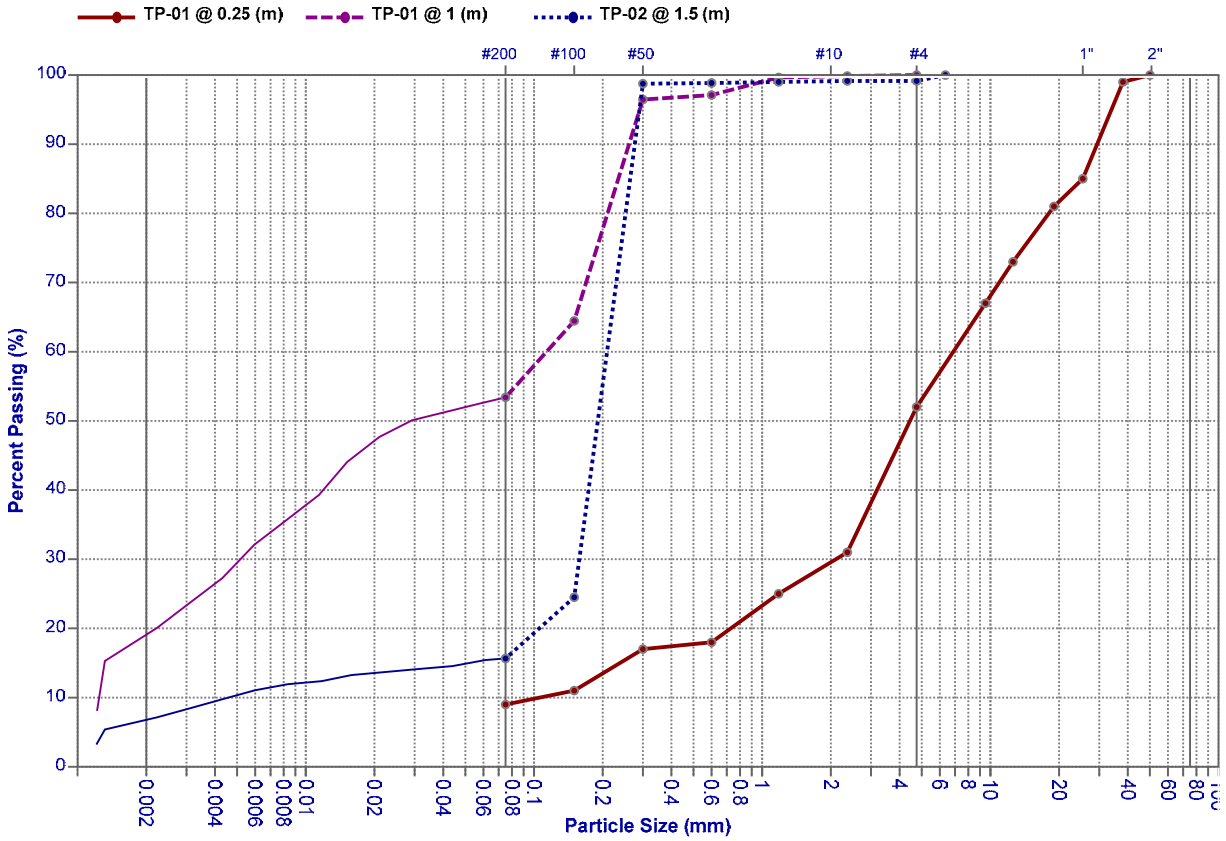
LTP-8

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	9	43	48	-
19.1	34.3	46.6	-	-
6.8	8.9	83.5	0.8	-

Classification

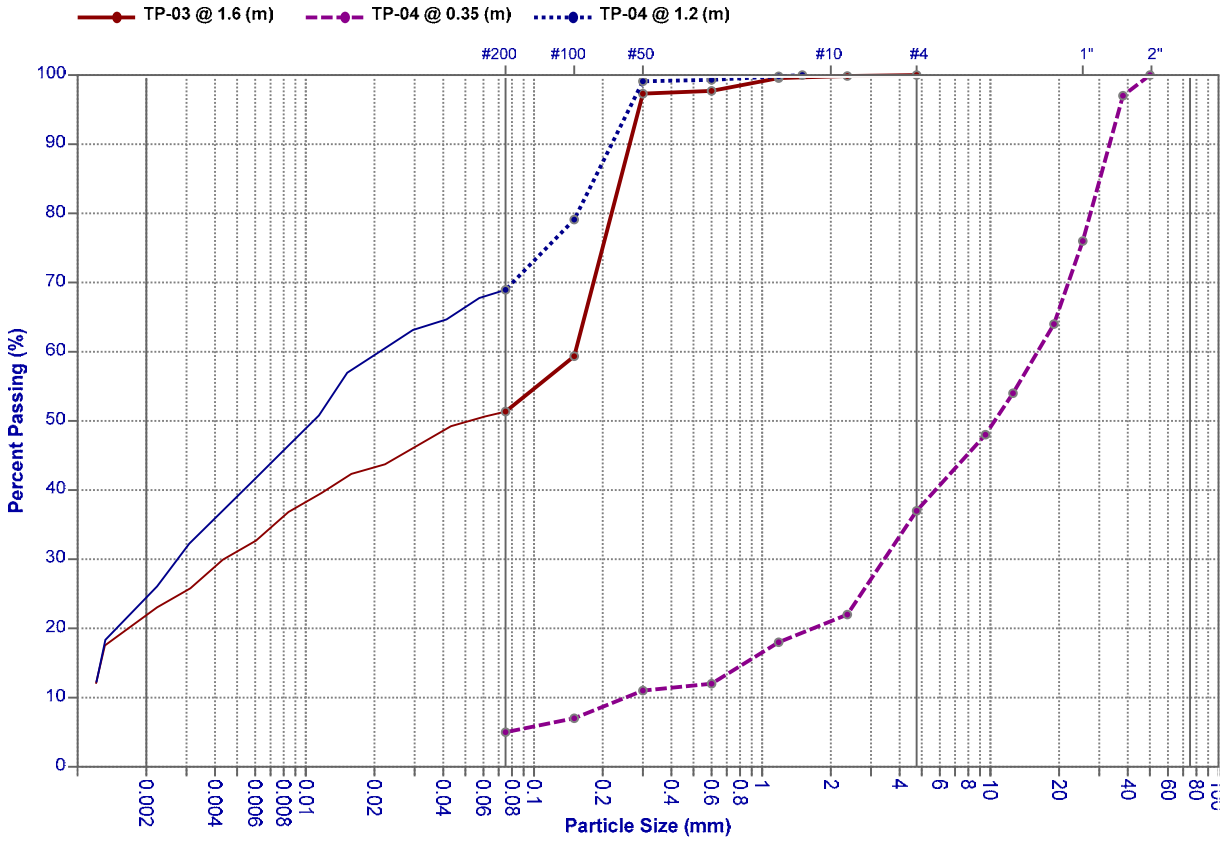
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-01	0.25	0.106	2.103	4.444	6.878	6.066	64.887	-	-	N/A	GP-GM	A-1-a
TP-01	1	0.001	0.005	0.029	0.113	0.221	113	-	-	N/A	ML	A-4
TP-02	1.5	0.005	0.158	0.19	0.209	23.889	41.8	-	-	N/A	SM	A-2-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
21.9	29.4	48.7	-	-
-	5	32	63	-
24.5	44.5	31.1	-	-

Classification

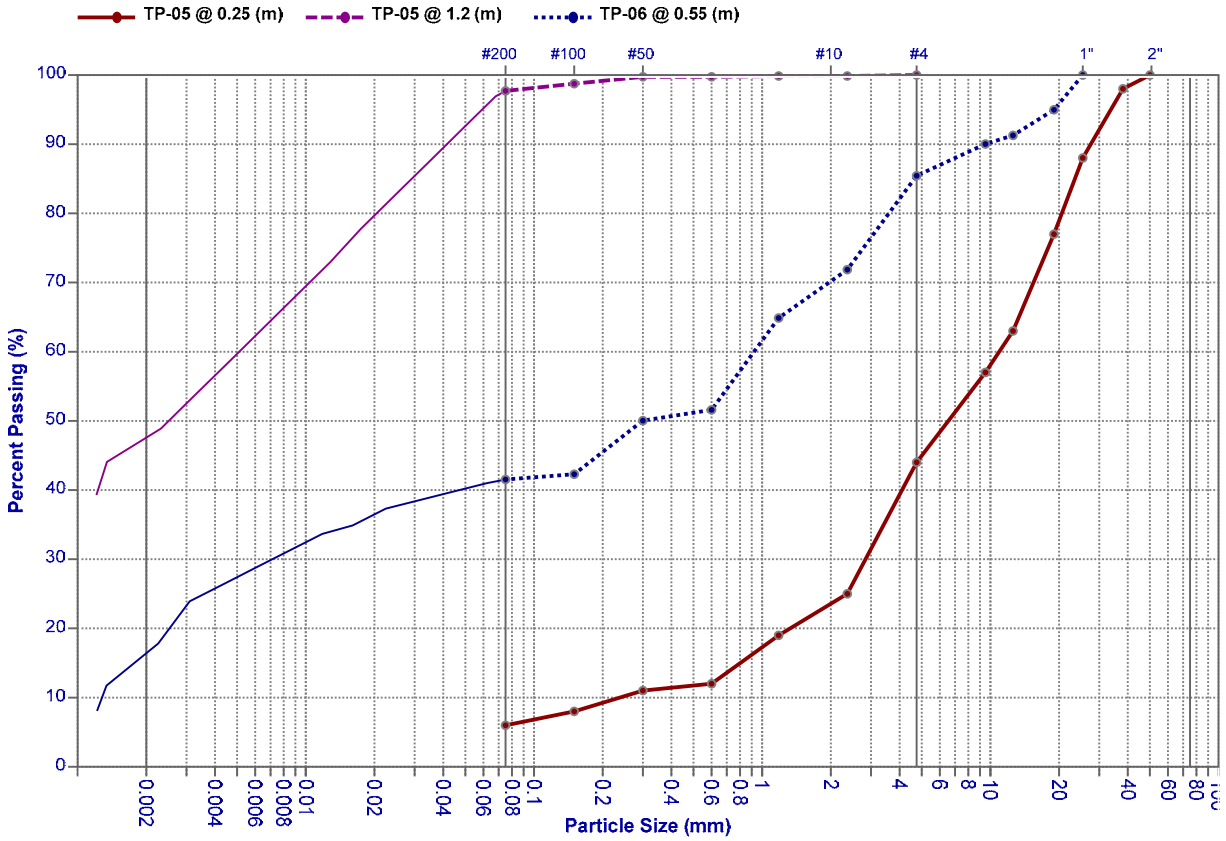
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-03	1.6	0.001	0.004	0.052	0.152	0.105	152	-	-	N/A	ML	A-4
TP-04	0.35	0.252	3.427	10.437	16.106	2.894	63.913	-	-	N/A	GW-GM	A-1-a
TP-04	1.2	0.001	0.003	0.011	0.021	0.429	21	-	-	N/A	ML	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	6	38	56	-
47.6	50.1	2.3	-	-
16.4	25.1	43.9	14.6	-

Classification

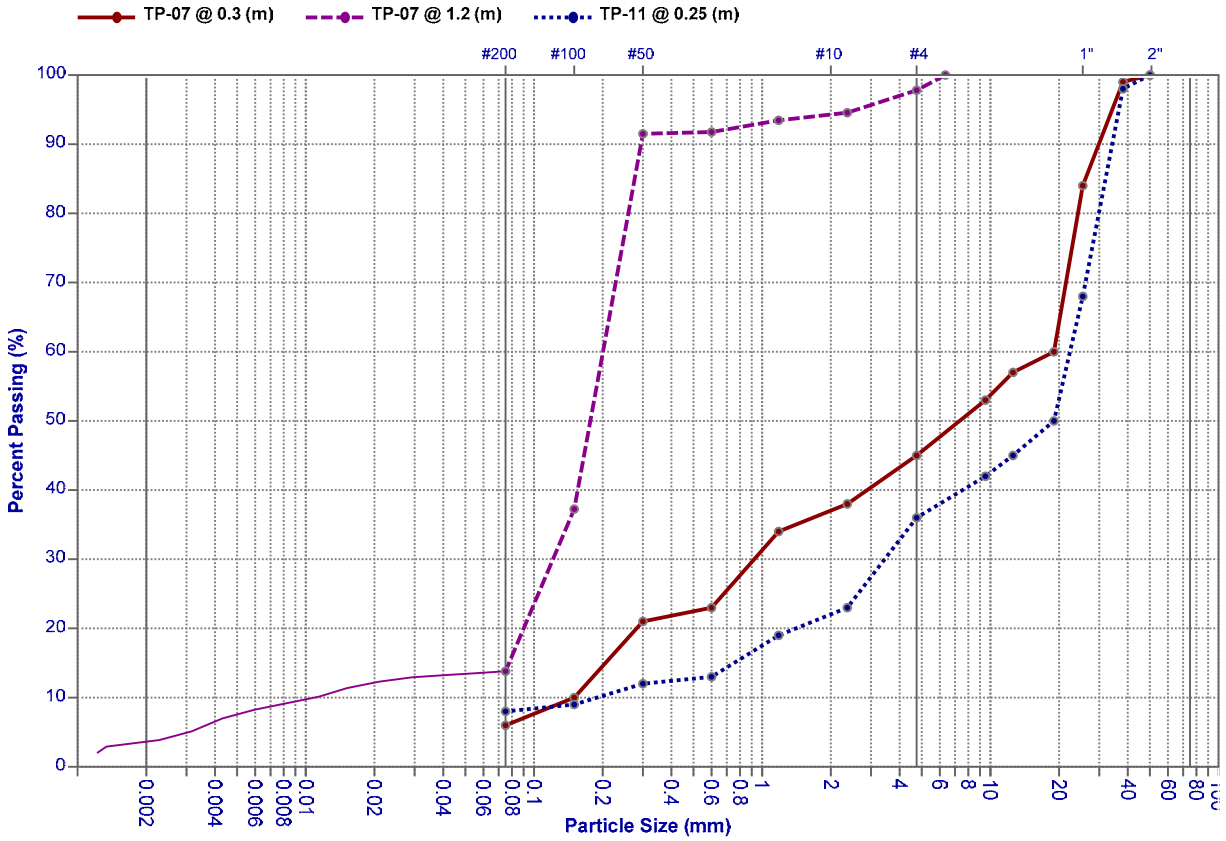
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-05	0.25	0.238	2.837	6.544	10.933	3.093	45.937	-	-	N/A	GP-GM	A-1-a
TP-05	1.2	0.001	0.001	0.003	0.005	0.2	5	14.1	3.1	N/A	ML	A-4
TP-06	0.55	0.001	0.007	0.3	0.921	0.053	921	-	-	N/A	SM	A-4

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	6	39	55	-
3.6	10.2	84	2.2	-
-	8	28	64	-

Classification

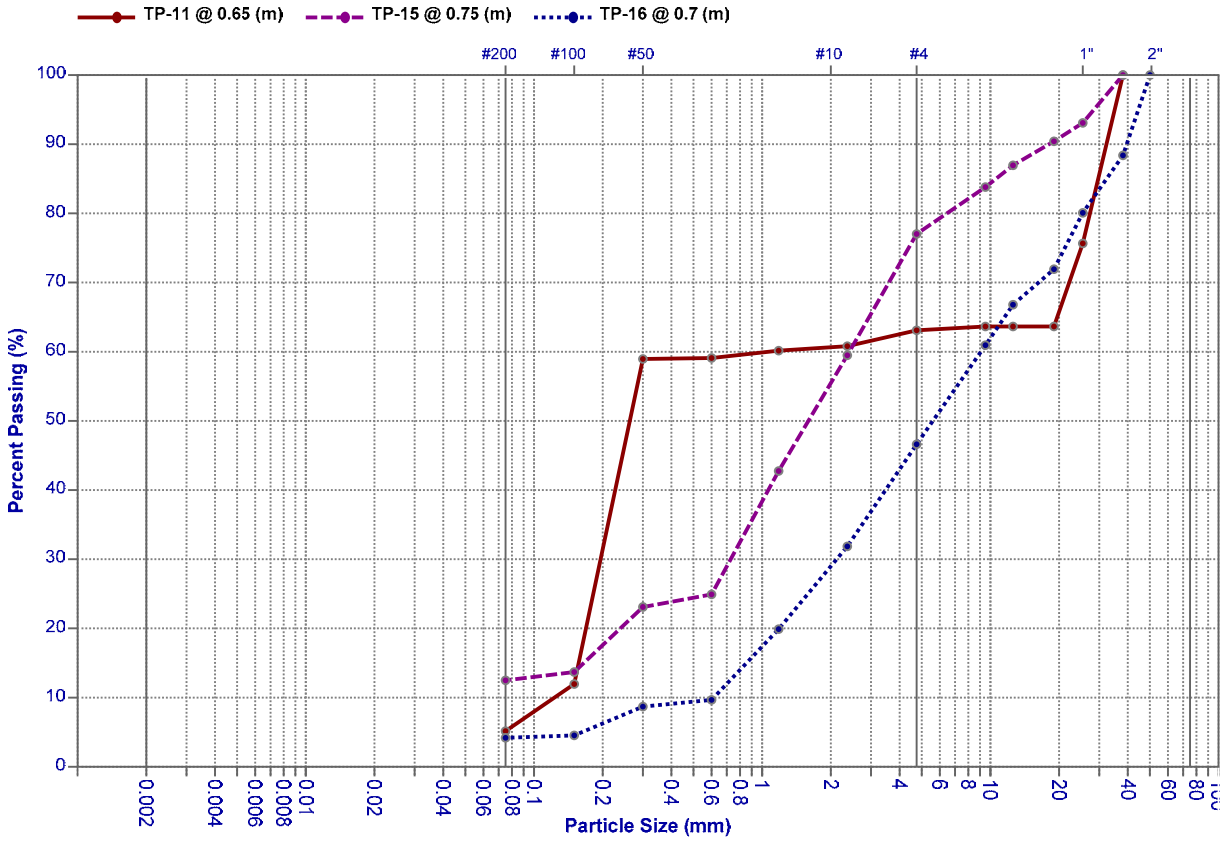
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-07	0.3	0.15	0.923	7.33	18.882	0.301	125.88	-	-	N/A	GP-GM	A-1-a
TP-07	1.2	0.011	0.121	0.177	0.201	6.622	18.273	-	-	N/A	SM	A-2-4
TP-11	0.25	0.189	3.439	18.917	22.325	2.803	118.122	-	-	N/A	GW-GM	A-1-a

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	5.1	58	36.9	-
-	12.5	64.5	23	-
-	4.2	42.4	53.4	-

Classification

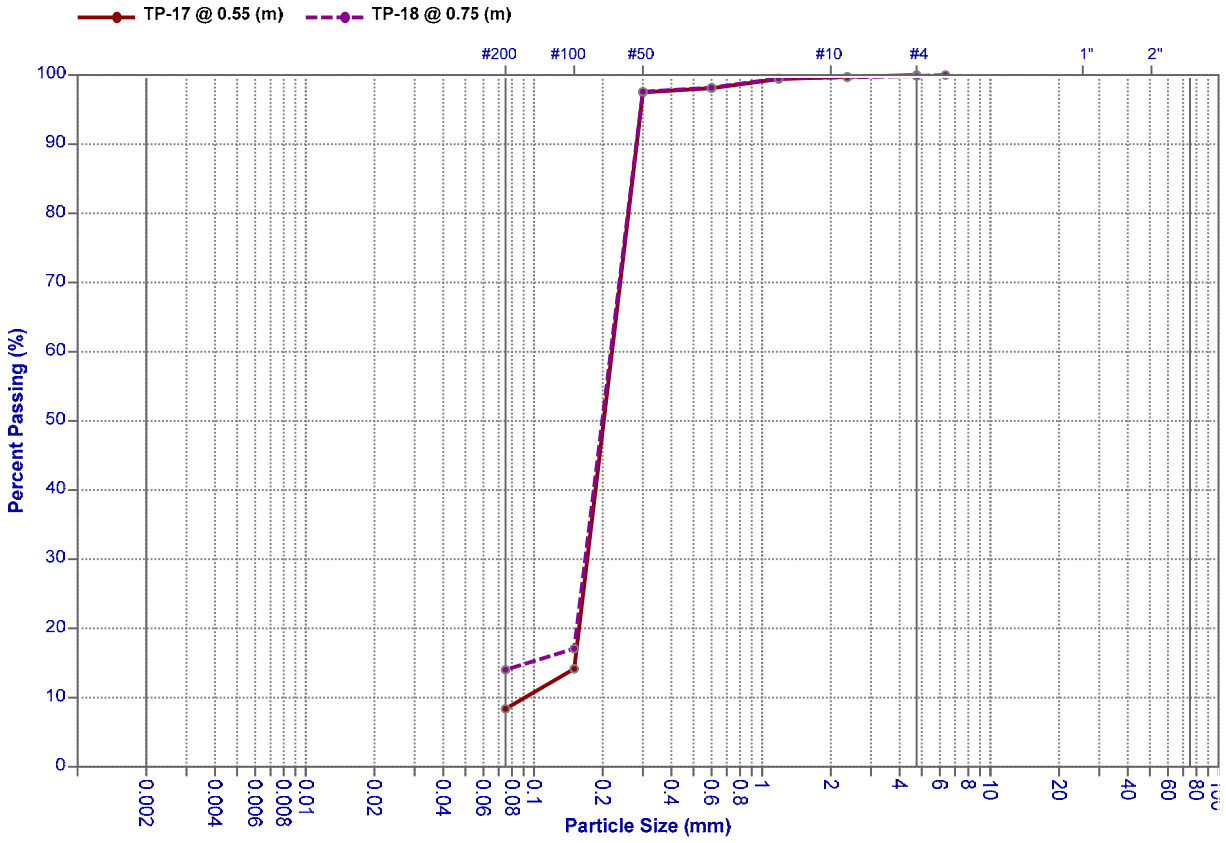
Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-11	0.65	0.123	0.196	0.263	1.071	0.292	8.707	-	-	N/A	SP-SM	A-2-4
TP-15	0.75	-	0.727	1.593	2.409	2.887	-	-	-	N/A	SM	A-2-4
TP-16	0.7	0.614	2.119	5.596	9.086	0.805	14.798	-	-	N/A	GP	A-1-a

Sieve Analysis Test

Project : GI for Yellow BRTS Line
Client : Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location : Korangi, Karachi

SOIL TESTING SERVICES

ASTM C136, D-6913



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
-	8.4	91.6	-	-
-	14	85.8	0.1	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
TP-17	0.55	0.091	0.171	0.202	0.22	1.461	2.418	-	-	N/A	SP-SM	A-2-4
TP-18	0.75	-	0.168	0.199	0.217	1.711	-	-	-	N/A	SM	A-2-4

ATTERBERG LIMITS TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-05
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	1.2 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

ASTM D-4318

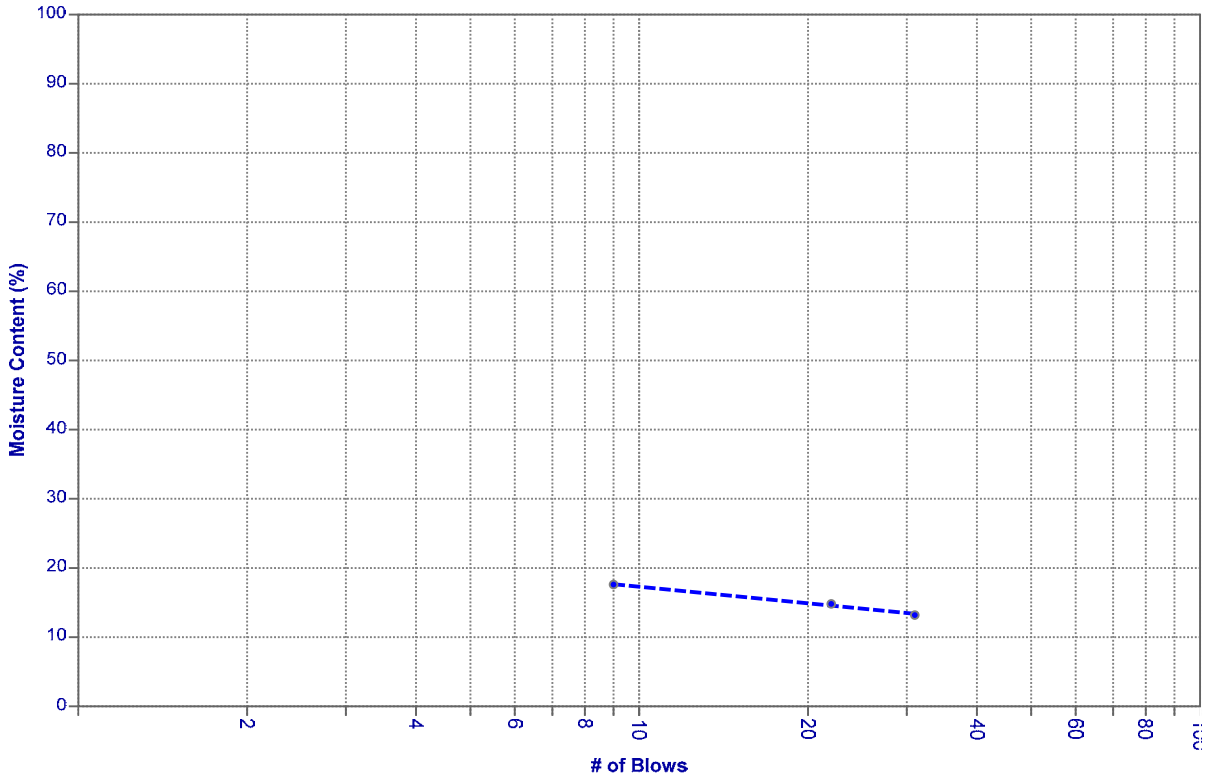
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
6.9	22.3	20	9	17.6
6.6	20.6	18.8	22	14.8
6.7	18.7	17.3	31	13.2
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
6.5	16.8	15.78	11

LL = 14.1 % **PL = 11 %** **PI=3.1**



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By :

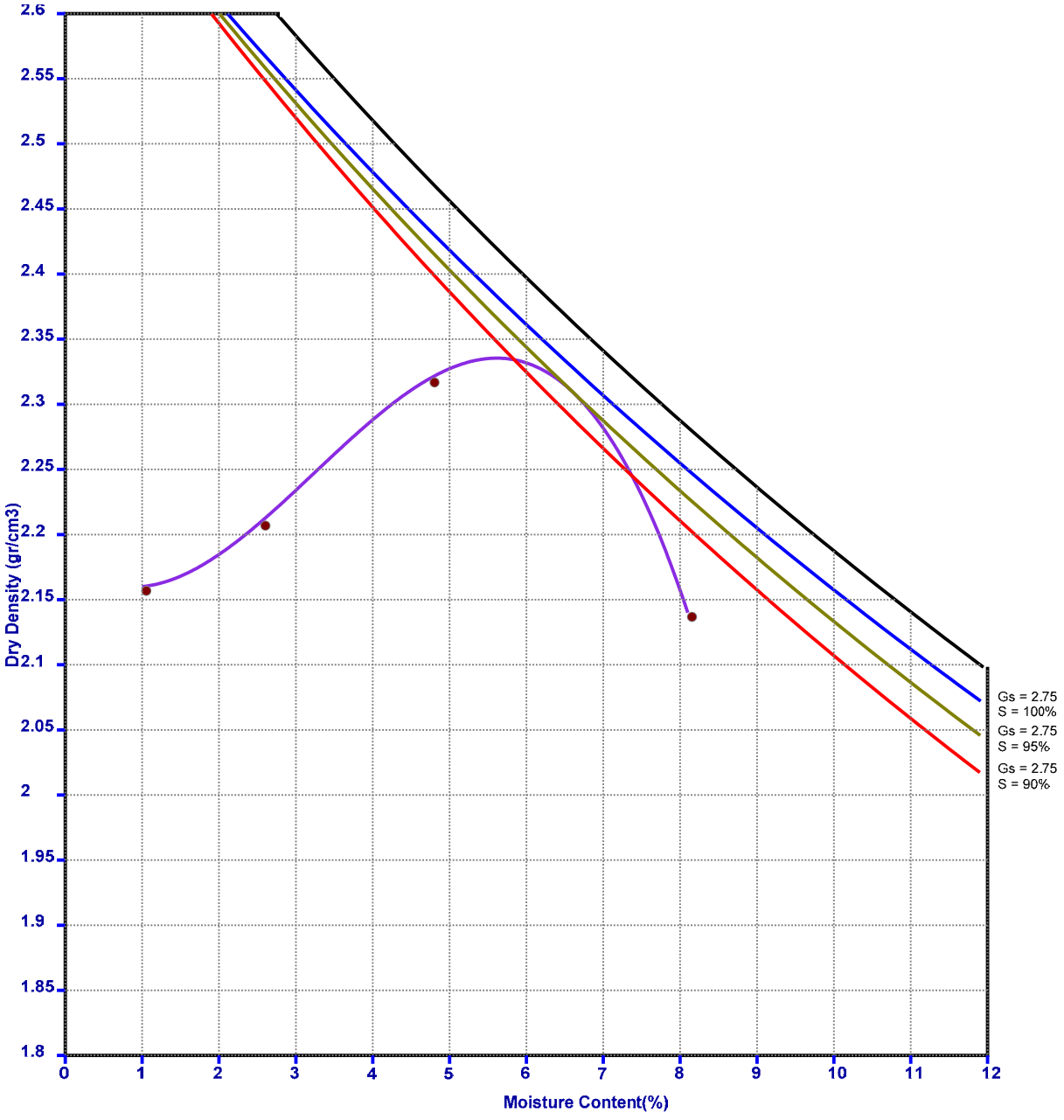
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-01
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.1-0.5 (m)
Job No.:	K19-1092-101	Classification :	GP-GM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.34	5.6	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Poorly Graded Silty Gravel With Sand & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

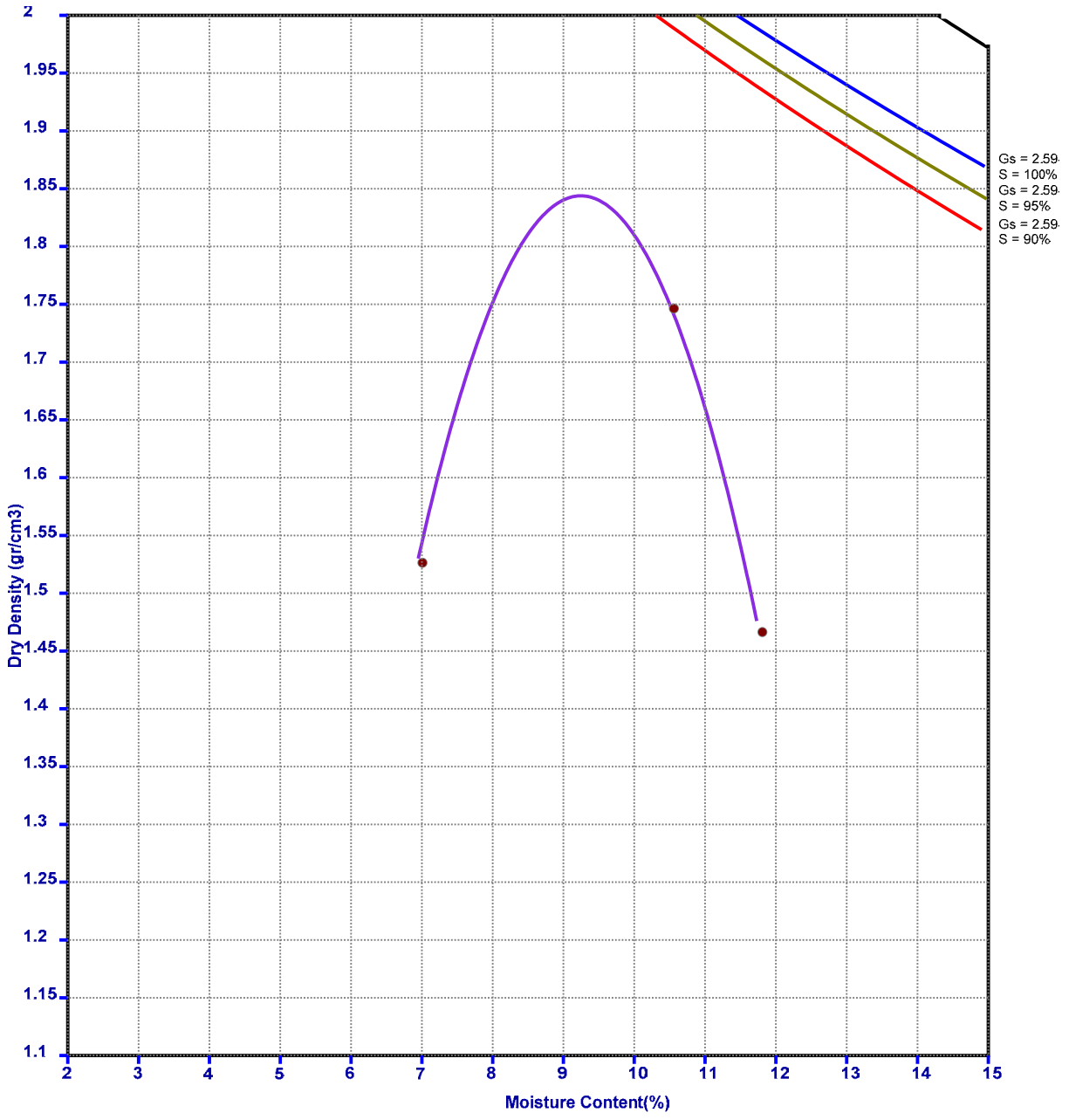
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-01
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.5-2.0 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.84	9.3	AASHTO T-180 (MOD.)	45.72	4.54	937.5	5 / 25



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By : AK

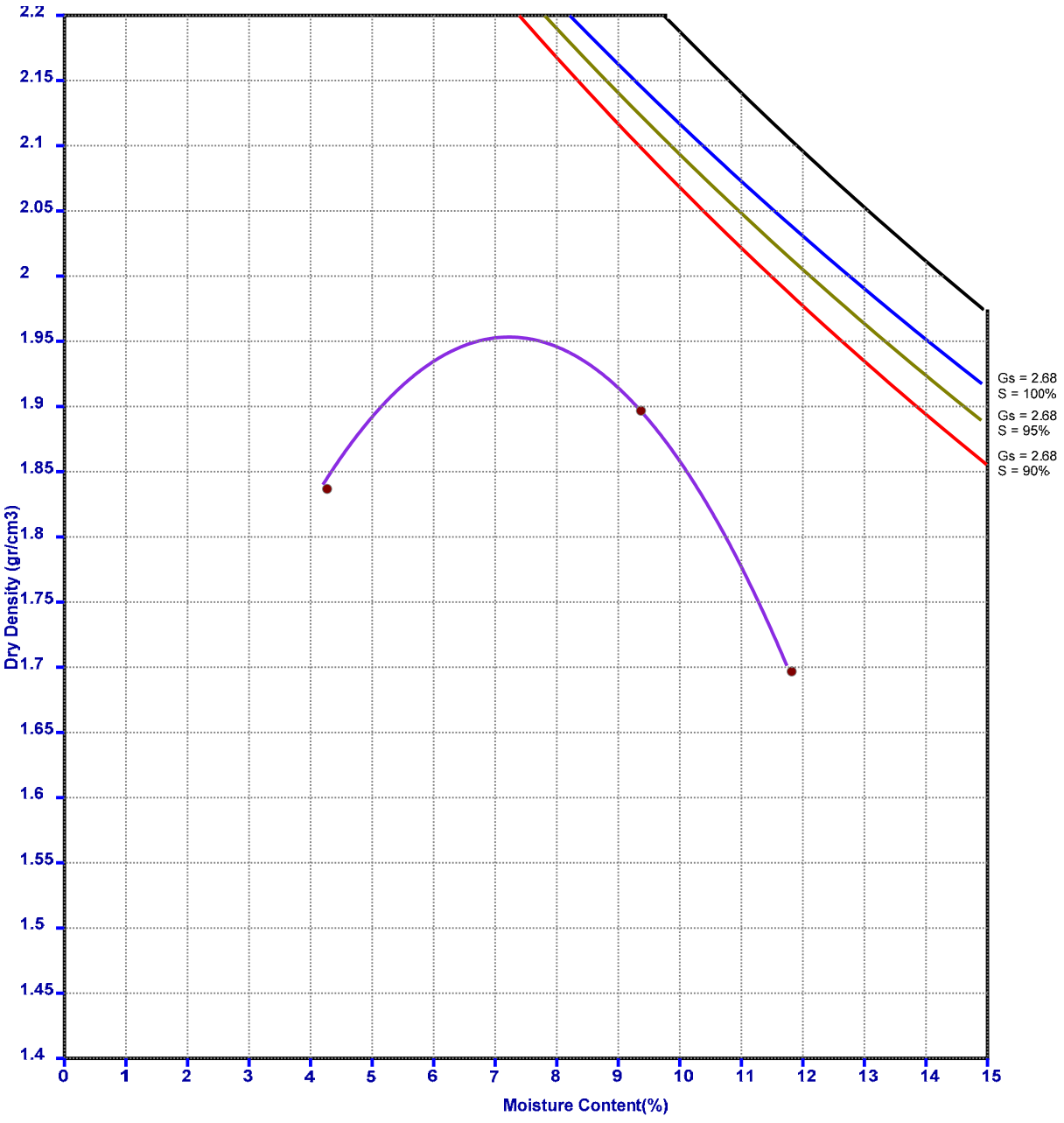
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-02
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	1.10-2.0 (m)
Job No.:	K19-1092-101	Classification :	SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.95	7.3	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Silty Sand With Gravel
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

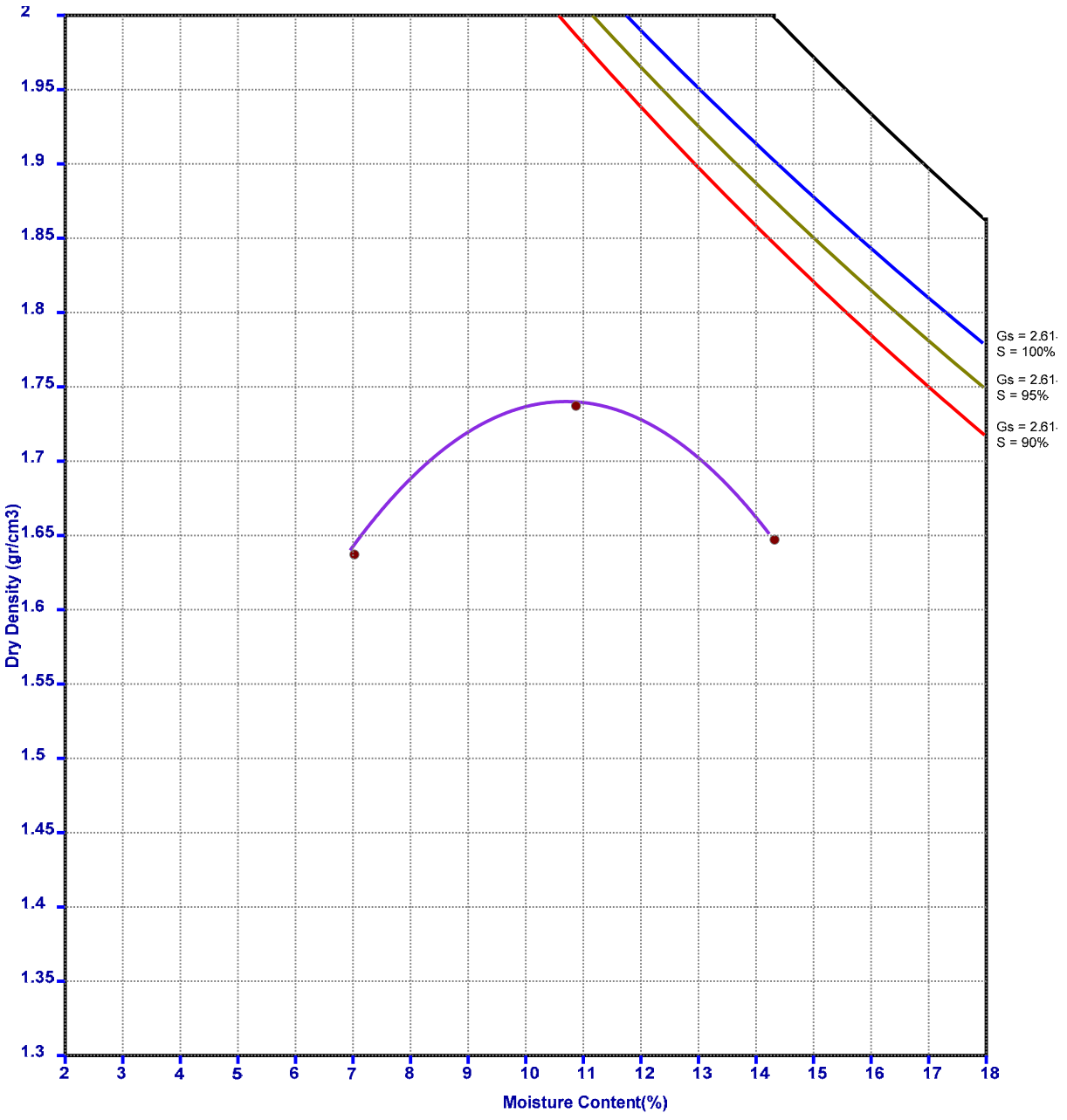
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-03
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.8-2.0 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.74	10.7	AASHTO T-180 (MOD.)	45.72	4.54	937.5	5 / 25



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By : AK

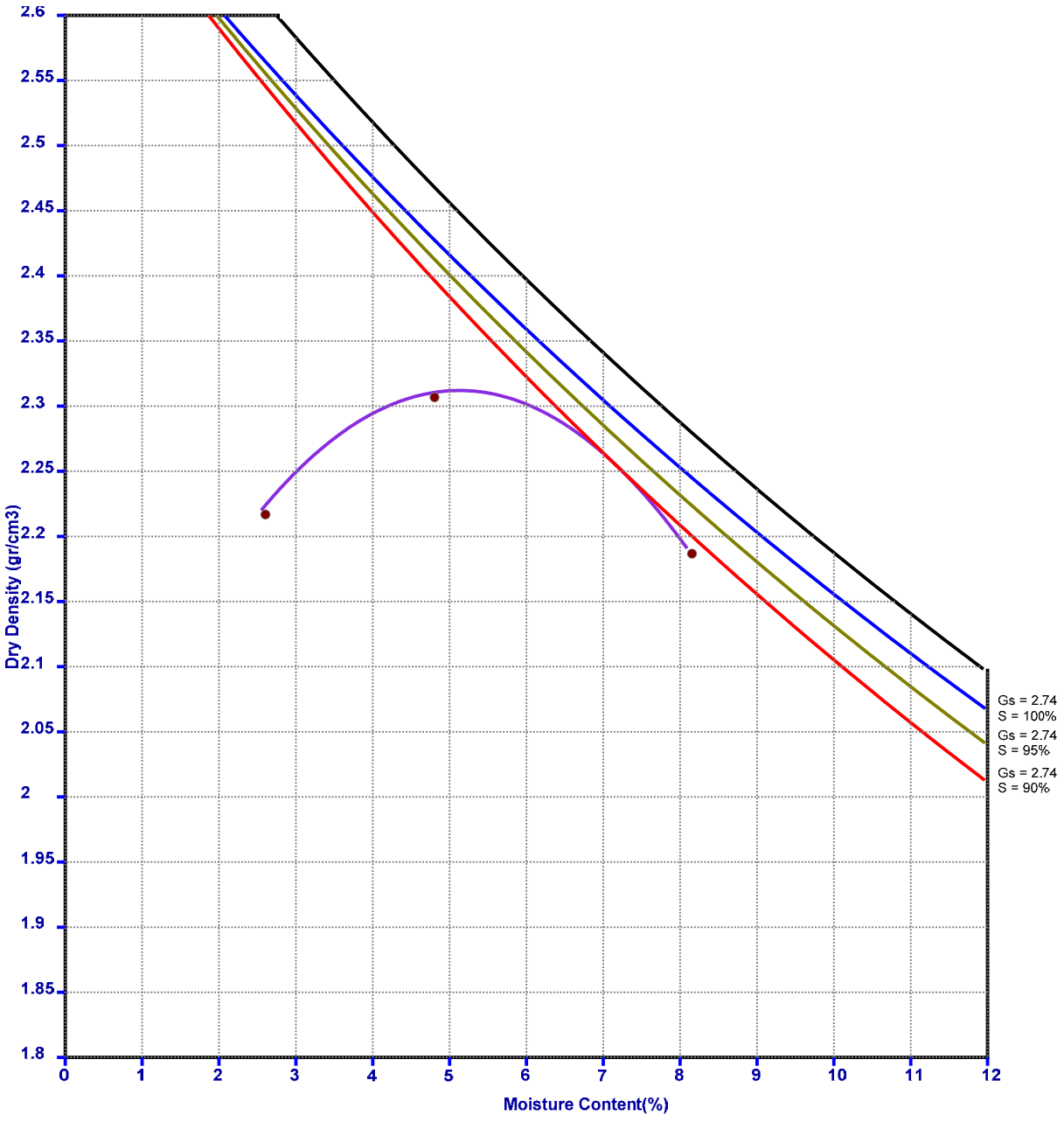
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-04
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.2-0.5 (m)
Job No.:	K19-1092-101	Classification :	GW-GM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.31	5.2	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Well Graded Silty Gravel With Sand & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

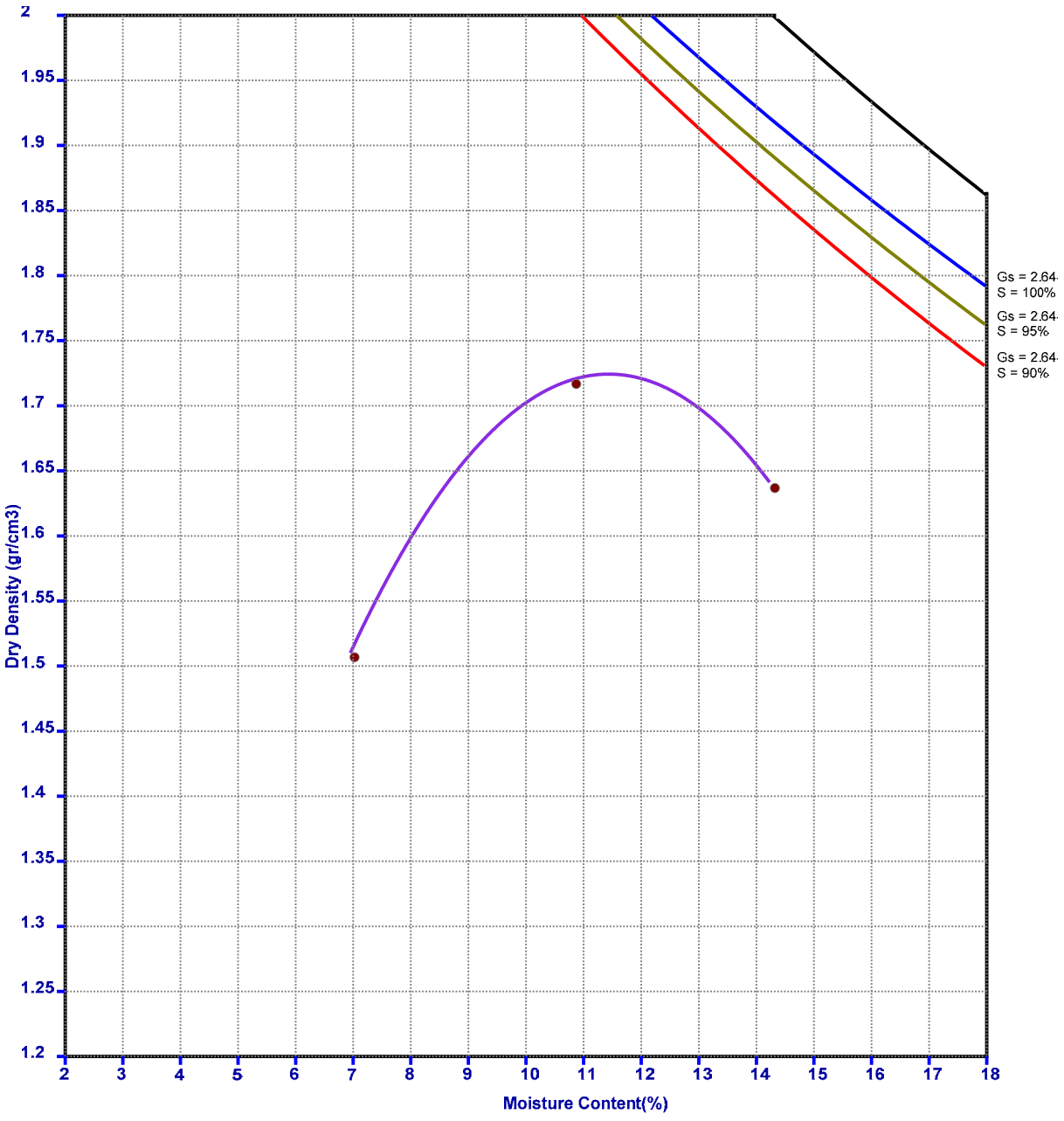
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-04
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.5-2.0 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.72	11.5	AASHTO T-180 (MOD.)	45.72	4.54	937.5	5 / 25



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By : AK

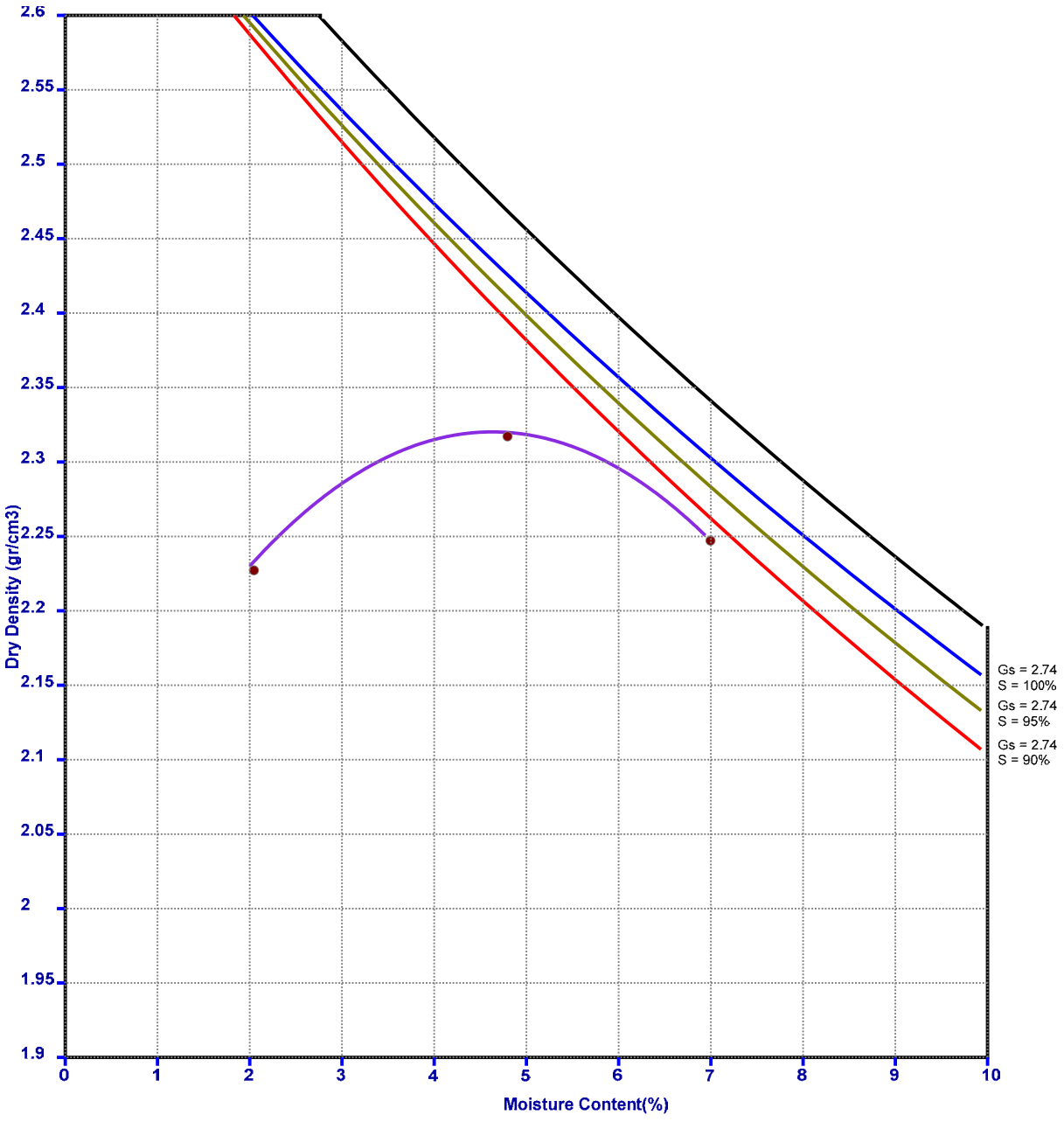
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-05
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.15 -0.45 (m)
Job No.:	K19-1092-101	Classification :	GP-GM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.32	4.7	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Poorly Graded Silty Gravel With Sand & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

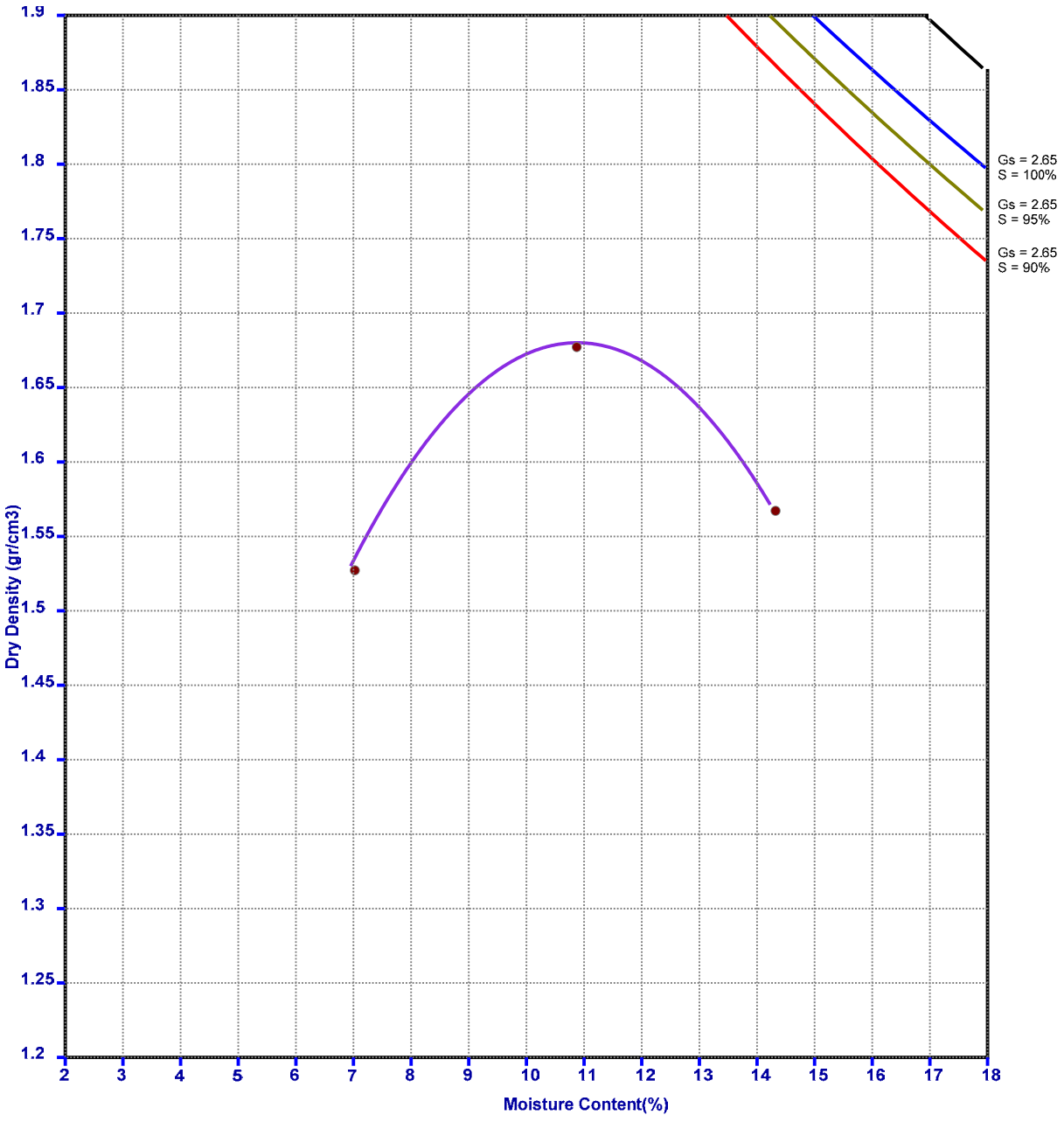
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-05
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.45-2.0 (m)
Job No.:	K19-1092-101	Classification :	ML
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.68	10.9	AASHTO T-180 (MOD.)	45.72	4.54	937.5	5 / 25



Unified Description : Low Plasticity Silt With Sand
AASHTO Description : A-4, Silty soils

Tested By : AK

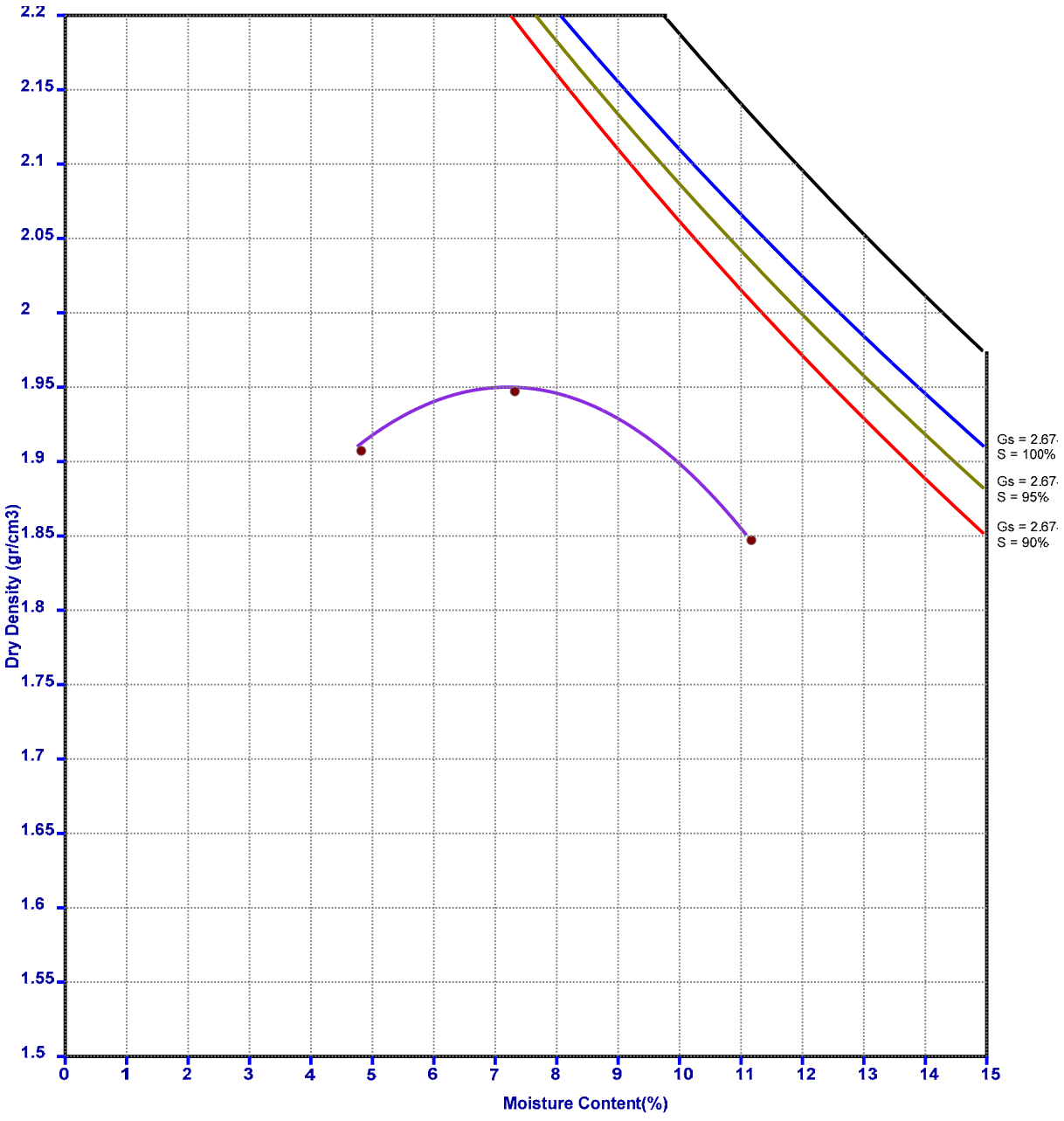
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-06
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.45-0.75 (m)
Job No.:	K19-1092-101	Classification :	SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
1.95	7.2	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Silty Sand With Gravel
AASHTO Description : A-4, Silty soils

Tested By : OR

COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-07
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.2-0.5 (m)
Job No.:	K19-1092-101	Classification :	GP-GM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.32	4.4	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56

Unified Description : Poorly Graded Silty Gravel With Sand & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

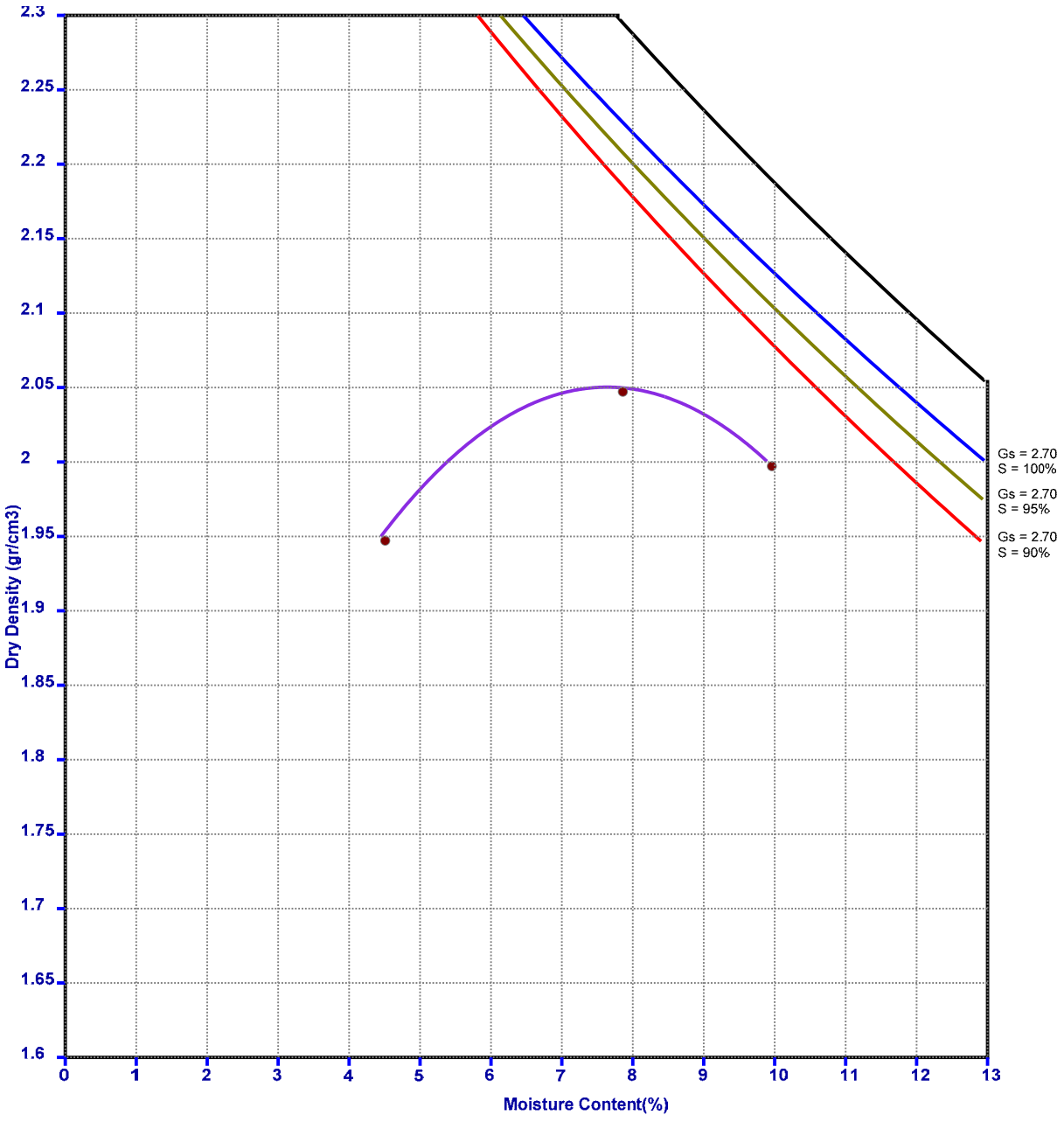
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-07
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	1.0-2.0 (m)
Job No.:	K19-1092-101	Classification :	SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.05	7.7	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Silty Sand With Gravel
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

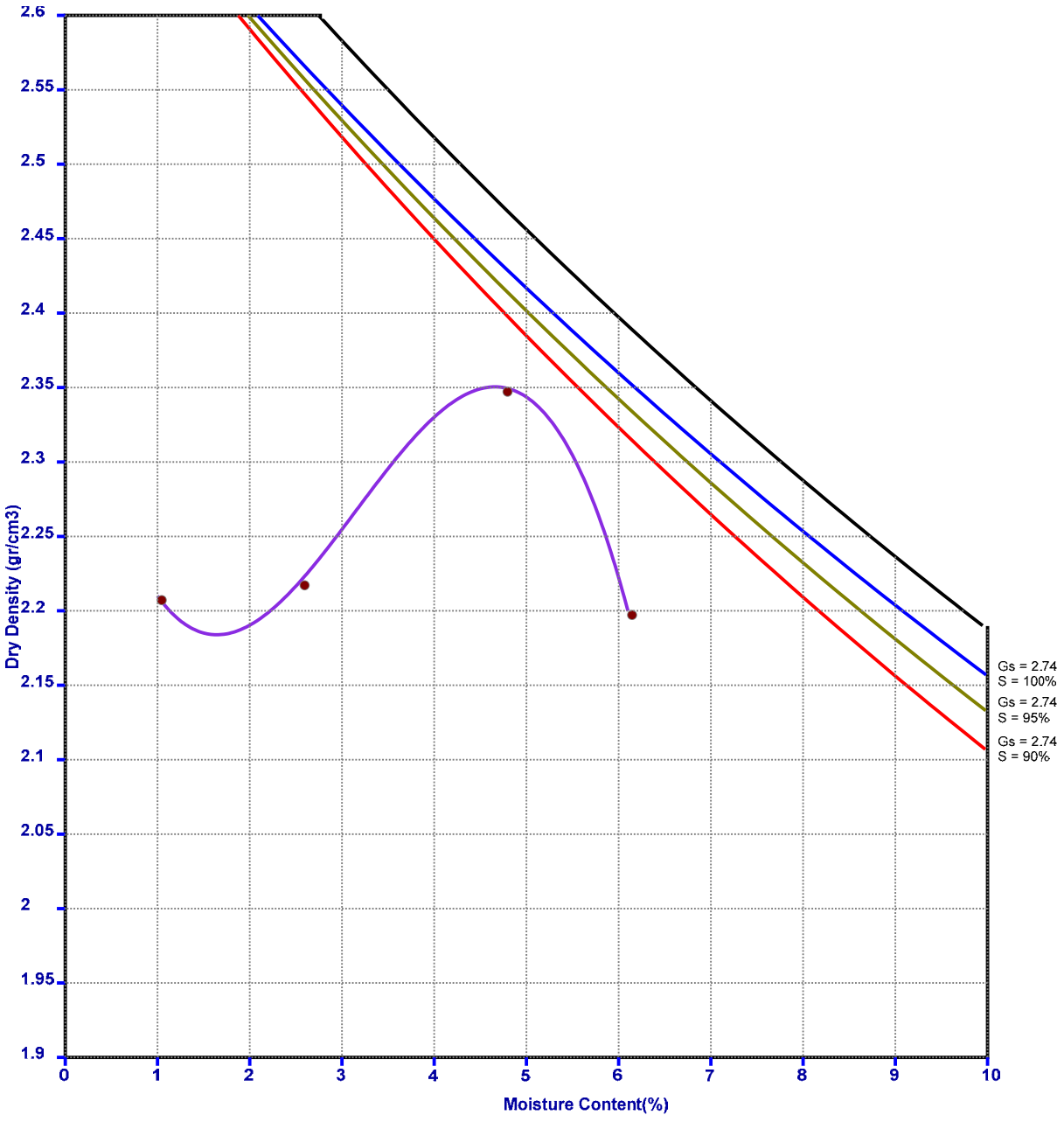
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-11
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.12-0.42 (m)
Job No.:	K19-1092-101	Classification :	GW-GM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.35	4.6	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Well Graded Silty Gravel With Sand & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

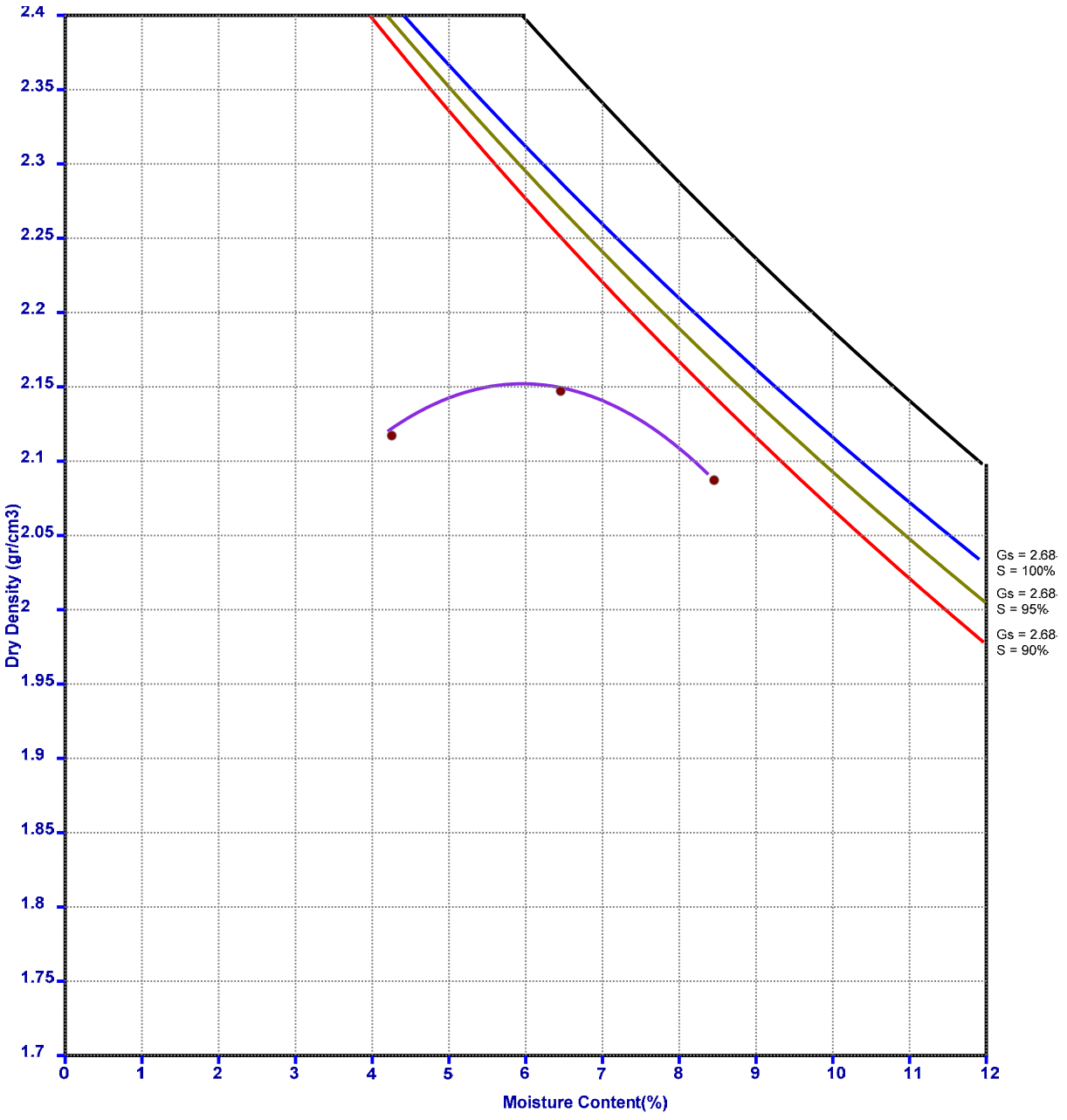
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-11
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.42-1.0 (m)
Job No.:	K19-1092-101	Classification :	SP-SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.15	6	ASTM D-1557 (MOD.)	45.72	4.54	2124	5 / 56



Unified Description : Poorly Graded Silty Sand With Gravel & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

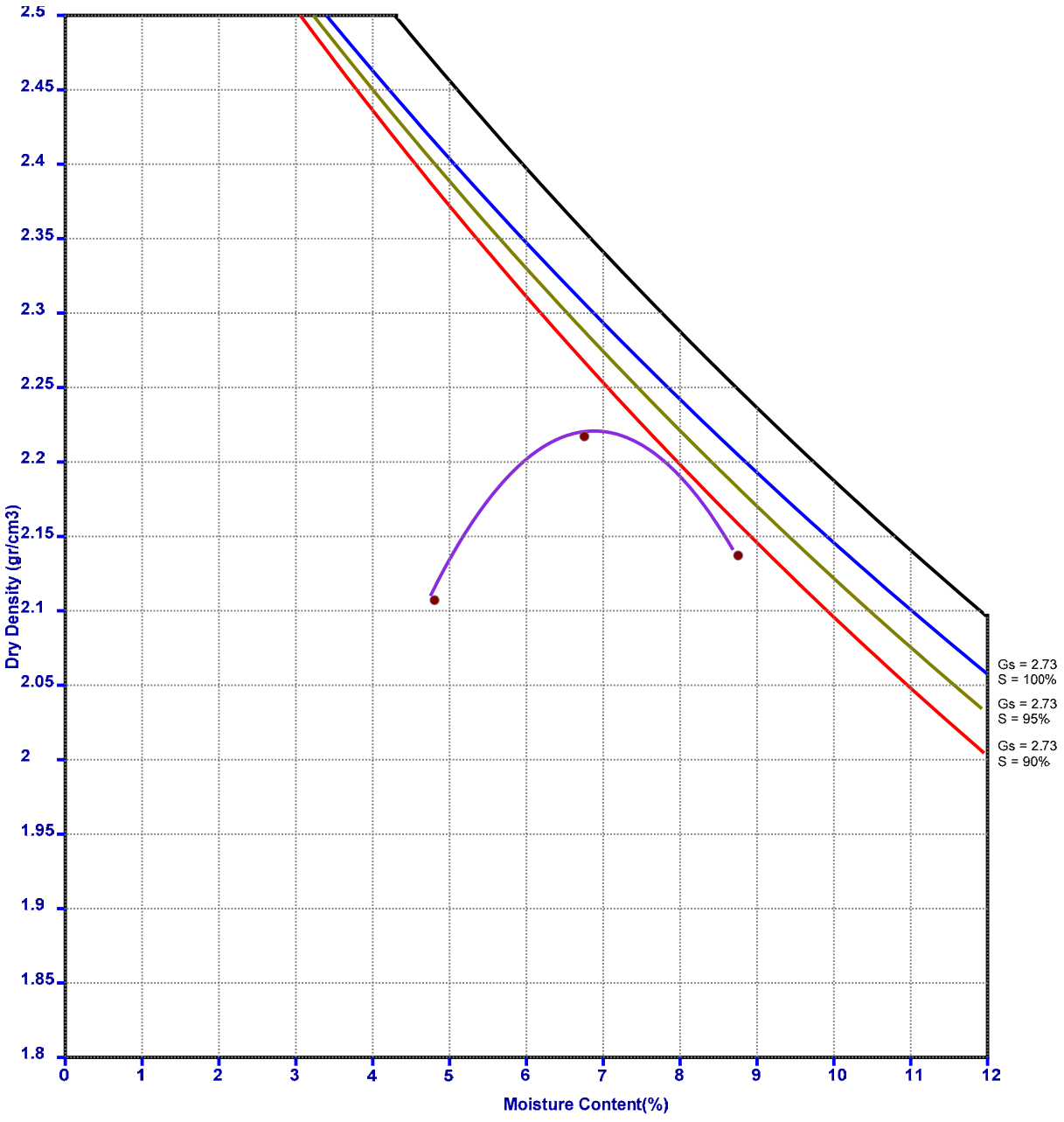
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-15
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.6-2.0 (m)
Job No.:	K19-1092-101	Classification :	SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.22	6.9	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Silty Sand With Gravel
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

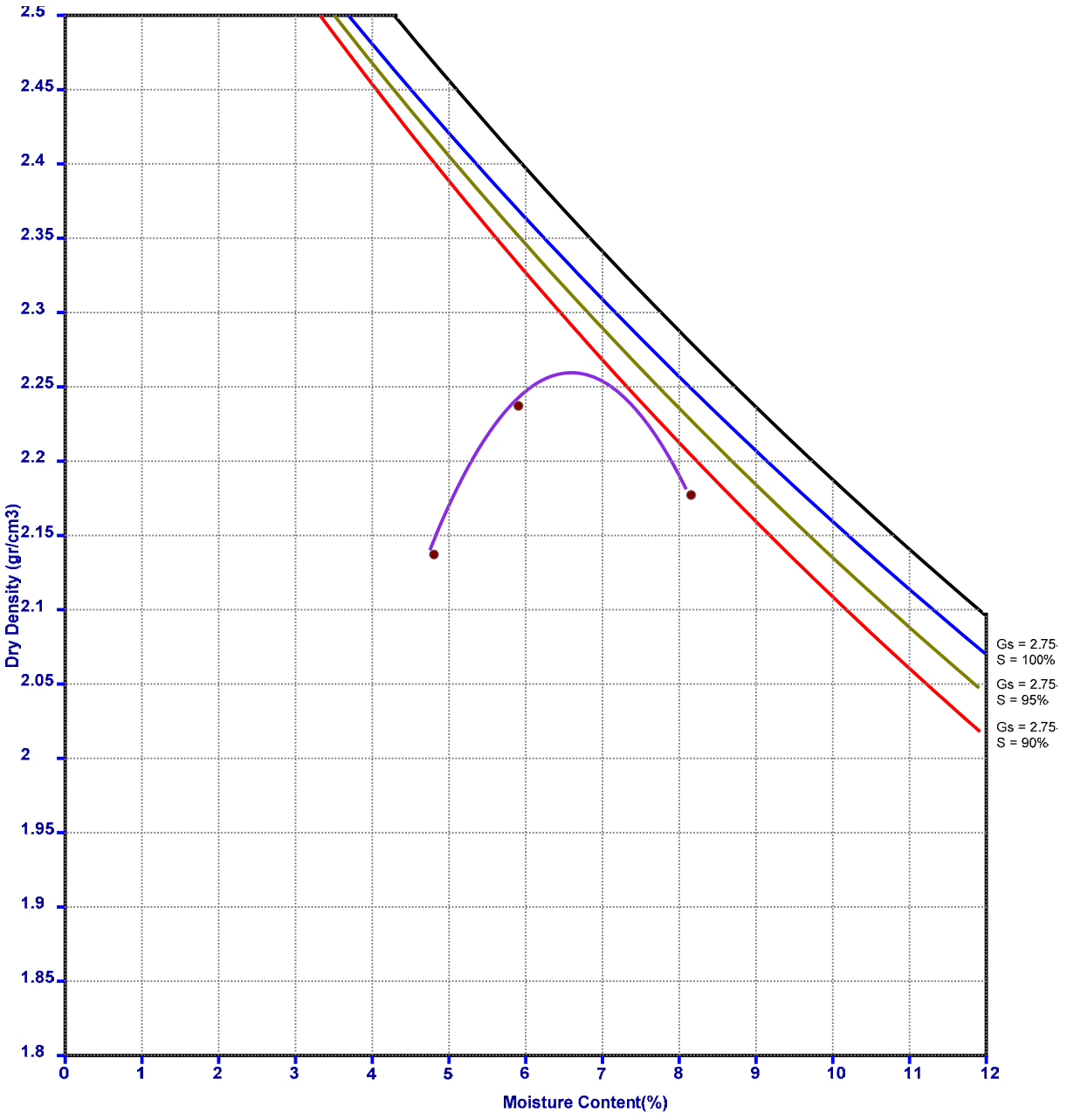
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-16
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.3-2.0 (m)
Job No.:	K19-1092-101	Classification :	GP
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.26	6.6	ASTM D-1557 (MOD.)	45.72	4.54	2209	5 / 56



Unified Description : Poorly Graded Gravel With Sand
AASHTO Description : Silty or clayey gravel and sand

Tested By : AK

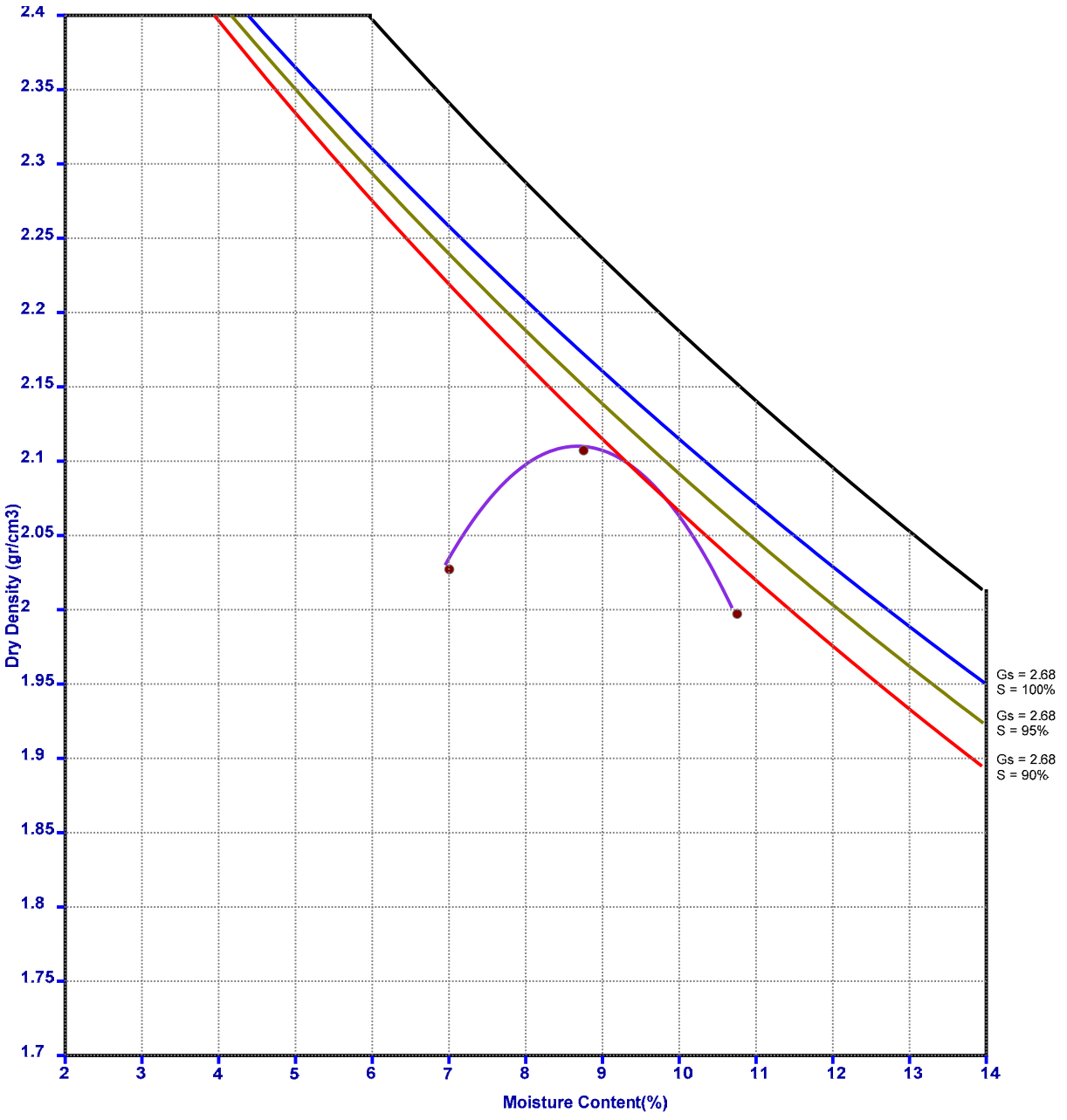
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-17
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.0 - 1.5 (m)
Job No.:	K19-1092-101	Classification :	SP-SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.11	8.7	AASHTO T-180 (MOD.)	45.72	4.54	937.47	5 / 25



Unified Description : Poorly Graded Silty Sand With Gravel & Clay
AASHTO Description : Silty or clayey gravel and sand

Tested By : OR

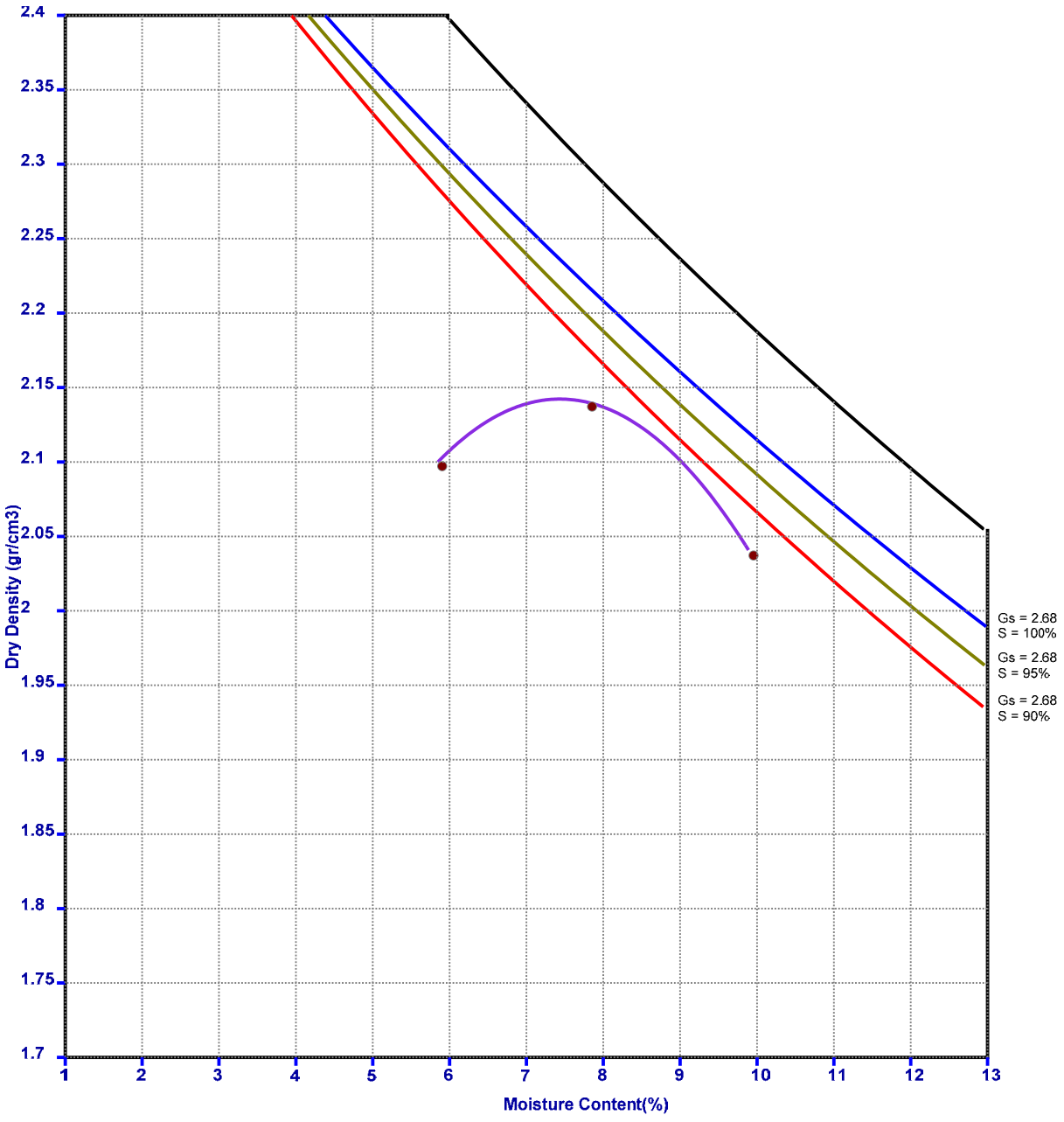
COMPACTION TEST

Project :	GI for Yellow BRTS Line	Borehole :	TP-18
Client :	Nespak (Pvt.) Ltd.	Sample Depth :	0.15-2.0 (m)
Job No.:	K19-1092-101	Classification :	SM
Location :	Korangi, Karachi	Sample Type :	Disturbed

SOIL TESTING SERVICES

Specifications & Results

Max. Dry Density (gr/cm3)	Optimum Moisture	Test Type	Drop Height (cm)	Hammer Weight	Mould Volume (cm3)	Blows/Layer
2.14	7.5	AASHTO T-180 (MOD.)	45.72	4.54	937.47	5 / 25



Unified Description : Silty Sand With Gravel
AASHTO Description : Silty or clayey gravel and sand

Tested By : OR

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 10.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2		1	2
	2	TEST Location		TP-01 10cm	TP-01 70cm		TP-02 20cm	TP-02 120cm
	3	DEPTH OF HOLE		8 Inch	6 Inch		8 Inch	6 Inch
	4	PROCTOR VALUE		2.34	1.84		-	1.95
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			5.15	7.65		2.45	5.98
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	11914	8426		12324	9562
	2	Wt. of Soil from hole	gm	9304	5010		9540	5120
	3	Wt. of Bottle+sand after test	gm	3206	2963		3350	3570
	4	Cone Calibration	gm	3265.33	1598		3265.33	1598
	5	Unit Wt. of Sand	gm/cc	1.434	1.434		1.434	1.434
	6	Volume of hole	cc	3795.45	2695.26		3980.94	3064.16
	7	Field Wet Density	gm/cc	2.45	1.86		2.40	1.67
	8	Field Moisture	%	5.15	7.65		2.45	5.98
	9	Field Dry Density	gm/cc	2.33	1.73		2.34	1.58
	10	Max. Proctor Value	gm/cc	2.34	1.84		-	1.95
	11	Percentage of Compaction	%	99.63	93.84		-	80.85
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 10.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2		1	2
	2	TEST Location		TP-03 20cm	TP-03 90cm		TP-04 20cm	TP-04 100cm
	3	DEPTH OF HOLE		8 Inch	6 Inch		8 Inch	6 Inch
	4	PROCTOR VALUE		-	1.74		2.31	1.72
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			3.45	7.65		4.65	8.45
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	11980	9746		12432	9424
	2	Wt. of Soil from hole	gm	10140	4547		9892	4378
	3	Wt. of Bottle+sand after test	gm	2302	4424		3114	3915
	4	Cone Calibration	gm	3265.33	1598		3265.33	1598
	5	Unit Wt. of Sand	gm/cc	1.434	1.434		1.434	1.434
	6	Volume of hole	cc	4471.88	2596.93		4220.83	2727.34
	7	Field Wet Density	gm/cc	2.27	1.75		2.34	1.61
	8	Field Moisture	%	3.45	7.65		4.65	8.45
	9	Field Dry Density	gm/cc	2.19	1.63		2.24	1.48
	10	Max. Proctor Value	gm/cc	-	1.74		2.31	1.72
	11	Percentage of Compaction	%	-	93.48		96.95	86.06
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 10.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2	3		
	2	TEST Location		TP-05 15cm	TP-05 60cm	TP-05 150cm		
	3	DEPTH OF HOLE		8 Inch	6 Inch	6 Inch		
	4	PROCTOR VALUE		2.32	1.68	1.68		
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			2.98	7.65	4.65		
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	13818	9368	9120		
	2	Wt. of Soil from hole	gm	9880	4565	4434		
	3	Wt. of Bottle+sand after test	gm	4274	3756	3830		
	4	Cone Calibration	gm	3265.33	1598	1598		
	5	Unit Wt. of Sand	gm/cc	1.434	1.434	1.434		
	6	Volume of hole	cc	4378.43	2799.16	2574.62		
	7	Field Wet Density	gm/cc	2.26	1.63	1.72		
	8	Field Moisture	%	2.98	7.65	4.65		
	9	Field Dry Density	gm/cc	2.19	1.51	1.65		
	10	Max. Proctor Value	gm/cc	2.32	1.68	1.68		
	11	Percentage of Compaction	%	94.45	90.18	97.96		
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: 21.10.2019

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 10.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2	1	2	3
	2	TEST Location		TP-06 15cm	TP-06 50cm	TP-07 20cm	TP-07 100cm	TP-07 170cm
	3	DEPTH OF HOLE		8 Inch	6 Inch	8 Inch	6 Inch	6 Inch
	4	PROCTOR VALUE		-	1.95	2.32	2.05	2.05
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			4.02	12.32	5.45	6.75	7.65
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	13274	9740	13400	8162	8022
	2	Wt. of Soil from hole	gm	9880	6120	8704	4297	4374
	3	Wt. of Bottle+sand after test	gm	3947	4108	4876	2406	2810
	4	Cone Calibration	gm	3265.33	1598	3265.33	1598	1598
	5	Unit Wt. of Sand	gm/cc	1.434	1.434	1.434	1.434	1.434
	6	Volume of hole	cc	4227.11	2813.11	3667.13	2899.58	2520.22
	7	Field Wet Density	gm/cc	2.34	2.18	2.37	1.48	1.74
	8	Field Moisture	%	4.02	12.32	5.45	6.75	7.65
	9	Field Dry Density	gm/cc	2.25	1.94	2.25	1.39	1.61
	10	Max. Proctor Value	gm/cc	-	1.95	2.32	2.05	2.05
	11	Percentage of Compaction	%	-	99.33	97.02	67.72	78.65
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 07.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2	1	2	3
	2	TEST Location		TP-09 10cm	TP-09 160cm	TP-10 12cm	TP-11 12cm	TP-11 50cm
	3	DEPTH OF HOLE		8 Inch	6 Inch	8 Inch	6 Inch	6 Inch
	4	PROCTOR VALUE		-	-	-	2.35	2.15
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			3.12	7.98	2.45	5.98	8.45
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	12002	7806	12002	12864	7934
	2	Wt. of Soil from hole	gm	8892	4858	9784	9156	4294
	3	Wt. of Bottle+sand after test	gm	3402	2324	2848	3564	3168
	4	Cone Calibration	gm	3265.33	1598	3265.33	3265.33	1598
	5	Unit Wt. of Sand	gm/cc	1.434	1.434	1.434	1.434	1.434
	6	Volume of hole	cc	3720.13	2708.51	4106.46	4208.28	2209.21
	7	Field Wet Density	gm/cc	2.39	1.79	2.38	2.18	1.94
	8	Field Moisture	%	3.12	7.98	2.45	5.98	8.45
	9	Field Dry Density	gm/cc	2.32	1.66	2.33	2.05	1.79
	10	Max. Proctor Value	gm/cc	-	-	-	2.35	2.15
	11	Percentage of Compaction	%	-	-	-	87.23	83.36
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: 21.10.2019

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 07.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2	1	2	3
	2	TEST Location		TP-12 24cm	TP-12 60cm	TP-13 20cm	TP-13 110cm	TP-13 170cm
	3	DEPTH OF HOLE		8 Inch	6 Inch	8 Inch	6 Inch	6 Inch
	4	PROCTOR VALUE		-	-	-	-	-
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			2.45	6.45	3.45	8.12	5.45
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	12286	7890	11780	7672	7824
	2	Wt. of Soil from hole	gm	9730	4200	9032	4382	4190
	3	Wt. of Bottle+sand after test	gm	2896	2987	2514	2630	2986
	4	Cone Calibration	gm	3265.33	1598	3265.33	1598	1598
	5	Unit Wt. of Sand	gm/cc	1.434	1.434	1.434	1.434	1.434
	6	Volume of hole	cc	4271.04	2304.74	4184.57	2401.67	2259.41
	7	Field Wet Density	gm/cc	2.28	1.82	2.16	1.82	1.85
	8	Field Moisture	%	2.45	6.45	3.45	8.12	5.45
	9	Field Dry Density	gm/cc	2.22	1.71	2.09	1.69	1.76
	10	Max. Proctor Value	gm/cc	-	-	-	-	-
	11	Percentage of Compaction	%	-	-	-	-	-
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 07.10.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1		1		
	2	TEST Location		TP-14 10cm		TP-14 140cm		
	3	DEPTH OF HOLE		8 Inch		6 Inch		
	4	PROCTOR VALUE		-		-		
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			3.15		6.98		
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	11364		8866		
	2	Wt. of Soil from hole	gm	9728		4800		
	3	Wt. of Bottle+sand after test	gm	2372		3490		
	4	Cone Calibration	gm	3265.33		1598		
	5	Unit Wt. of Sand	gm/cc	1.434		1.434		
	6	Volume of hole	cc	3993.49		2634.59		
	7	Field Wet Density	gm/cc	2.44		1.82		
	8	Field Moisture	%	3.15		6.98		
	9	Field Dry Density	gm/cc	2.36		1.70		
	10	Max. Proctor Value	gm/cc	-		-		
	11	Percentage of Compaction	%	-		-		
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 15.07.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2		1	2
	2	TEST Location		TP-15 60cm	TP-15 140cm		TP-16 80cm	TP-16 170cm
	3	DEPTH OF HOLE		6 Inch	6 Inch		6 Inch	6 Inch
	4	PROCTOR VALUE		2.22	2.22		2.26	2.26
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			7.12	7.65		6.95	6.15
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	8452	8198		7944	7780
	2	Wt. of Soil from hole	gm	4440	4274		6222	4452
	3	Wt. of Bottle+sand after test	gm	3300	2670		1722	2840
	4	Cone Calibration	gm	1598	1598		1598	1598
	5	Unit Wt. of Sand	gm/cc	1.414	1.414		1.414	1.414
	6	Volume of hole	cc	2513.44	2779.35		3270.16	2363.51
	7	Field Wet Density	gm/cc	1.77	1.54		1.90	1.88
	8	Field Moisture	%	7.12	7.65		6.95	6.15
	9	Field Dry Density	gm/cc	1.65	1.43		1.78	1.77
	10	Max. Proctor Value	gm/cc	2.22	2.22		2.26	2.26
	11	Percentage of Compaction	%	74.28	64.35		78.72	78.52
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

Date: **21.10.2019**

DETERMINATION OF DENSITY
IN SITU BY SAND CONE METHOD
(AASHTO T-191-93) (ASTM D 1556-90)

Project : Construction Of Yellow BRTS Line **L.R. No. :** K19-1092-101

Client : Nespak (Pvt.) Ltd.

LOCATION Korangi, Karachi **Date:** 20.09.2019 **Layers :** - **Soil :** -

(A)	**TEST NO.**							
	1	F.D. TEST NO.		1	2		1	2
	2	TEST Location		TP-17 70cm	TP-17 110cm		TP-18 50cm	TP-18 150cm
	3	DEPTH OF HOLE		6 Inch	6 Inch		6 Inch	6 Inch
	4	PROCTOR VALUE		2.11	2.11		2.14	2.14
(B)	**MOISTURE CONTENT (OVEN DRY METHOD) %**			7.65	8.12		7.66	8.65
(C)	**FIELD DENSITY**							
	1	Wt. of Bottle+sand before test	gm	8140	7598		7568	8432
	2	Wt. of Soil from hole	gm	4400	4758		4484	4790
	3	Wt. of Bottle+sand after test	gm	2890	2338		2550	2968
	4	Cone Calibration	gm	1598	1598		1598	1598
	5	Unit Wt. of Sand	gm/cc	1.414	1.414		1.414	1.414
	6	Volume of hole	cc	2582.74	2589.82		2418.67	2734.09
	7	Field Wet Density	gm/cc	1.70	1.84		1.85	1.75
	8	Field Moisture	%	7.65	8.12		7.66	8.65
	9	Field Dry Density	gm/cc	1.58	1.70		1.72	1.61
	10	Max. Proctor Value	gm/cc	2.11	2.11		2.14	2.14
	11	Percentage of Compaction	%	75.00	80.53		80.47	75.35
	12	REQUIRED COMPACTION	%					
		Status						

REMARKS :

Consultants

Mr. Omais Rizwan
Tested By

Signature:

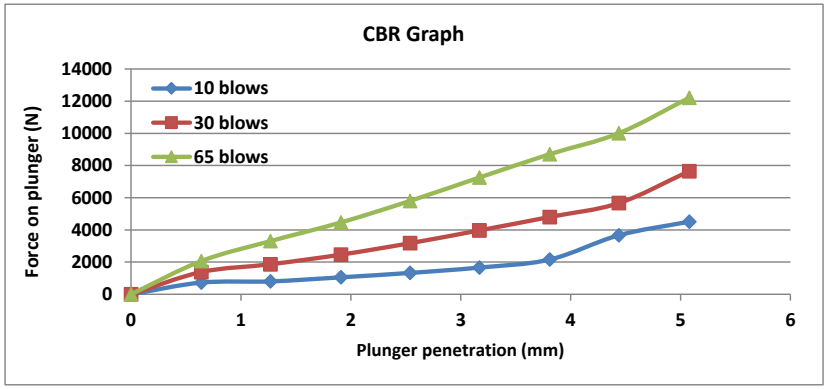
Date: **21.10.2019**

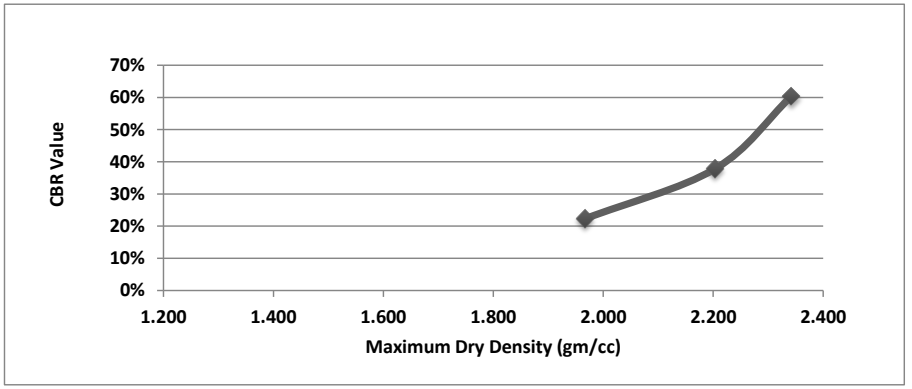
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-01
Depth : 0.1-0.5 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.97	1.86	5.60	11.45	0.000	4.5 kg	22.30
30 blows	2.20	2.12	5.60	9.65	0.000		37.82
65 blows	2.34	2.31	5.60	7.15	0.000		60.37



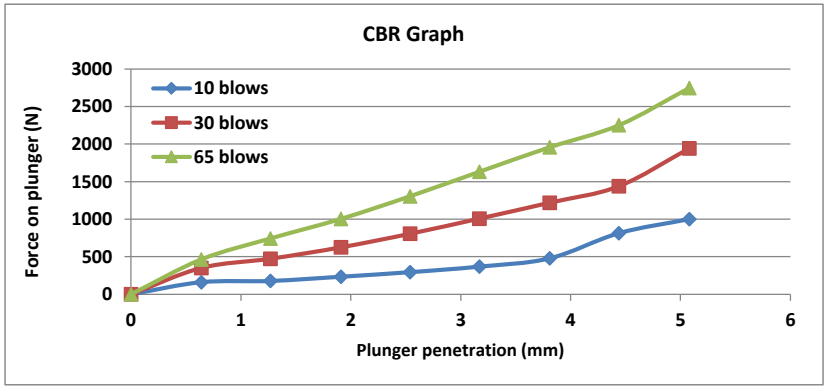


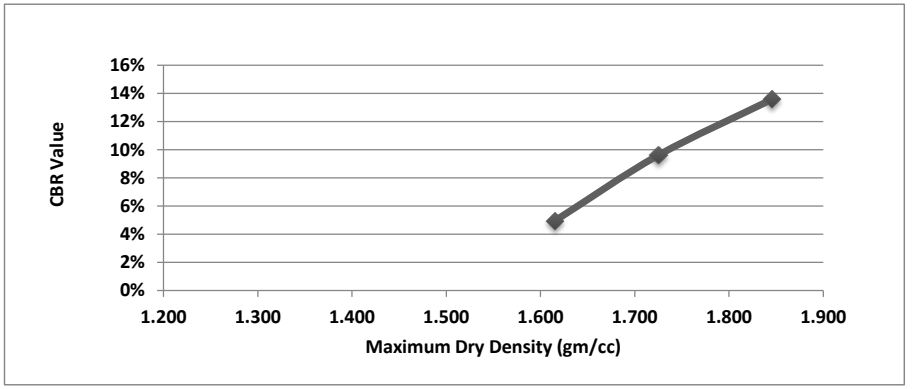
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-01
Depth : 0.5-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.62	1.48	9.30	19.65	0.450	4.5 kg	4.95
30 blows	1.72	1.62	9.30	16.32	0.280		9.60
65 blows	1.85	1.76	9.30	14.55	0.160		13.58



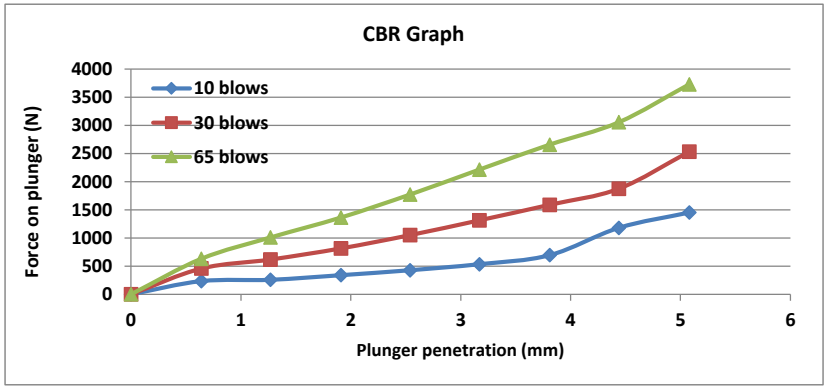


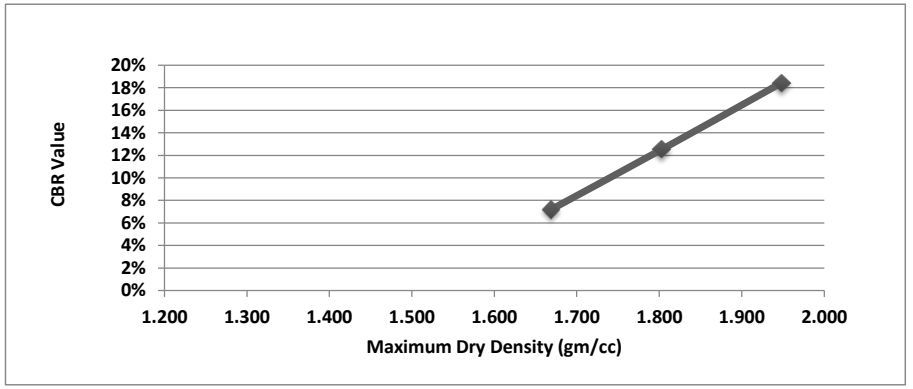
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-02
Depth : 1.10-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.67	1.55	7.25	15.65	0.000	4.5 kg	7.18
30 blows	1.80	1.70	7.25	13.45	0.000		12.51
65 blows	1.95	1.90	7.25	10.11	0.000		18.43



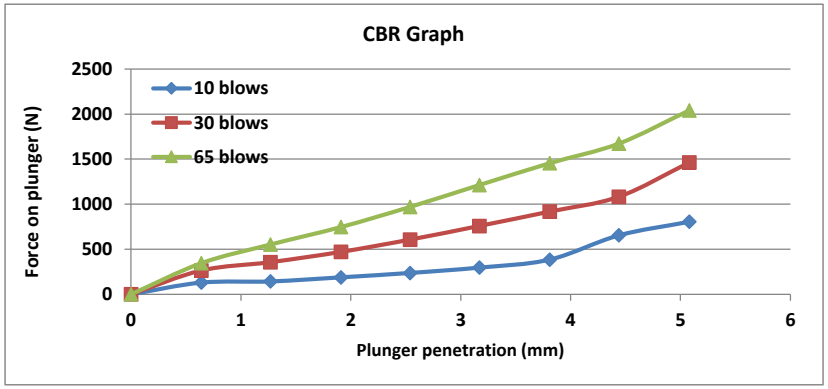


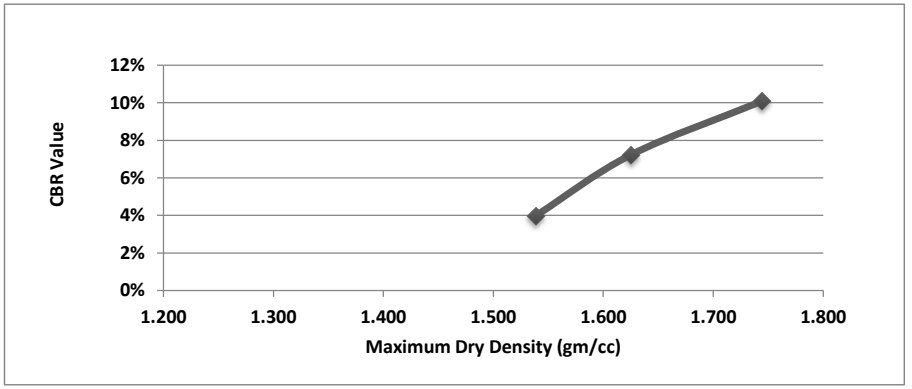
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-03
Depth : 0.8-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.54	1.39	10.70	22.45	0.360	4.5 kg	3.98
30 blows	1.63	1.50	10.70	19.65	0.560		7.22
65 blows	1.74	1.68	10.70	15.11	0.980		10.09



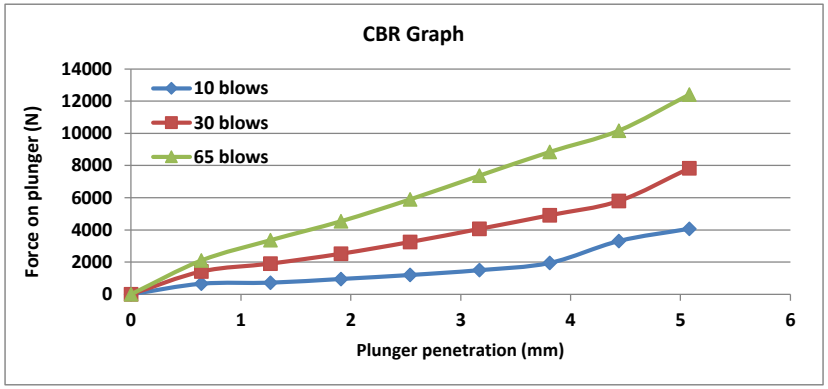


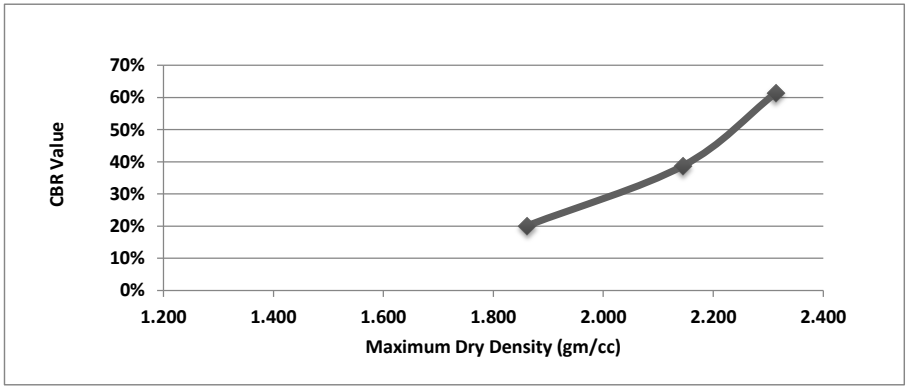
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-04
Depth : 0.20-0.50 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.86	1.74	5.15	12.32	0.000	4.5 kg	20.12
30 blows	2.14	2.04	5.15	10.45	0.000		38.69
65 blows	2.31	2.26	5.15	7.66	0.000		61.34



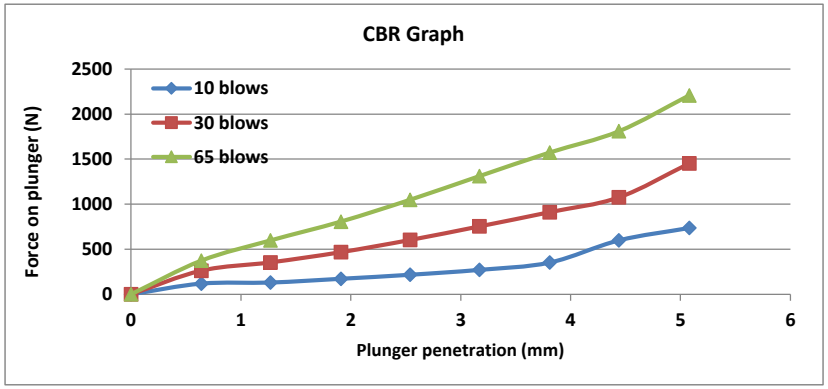


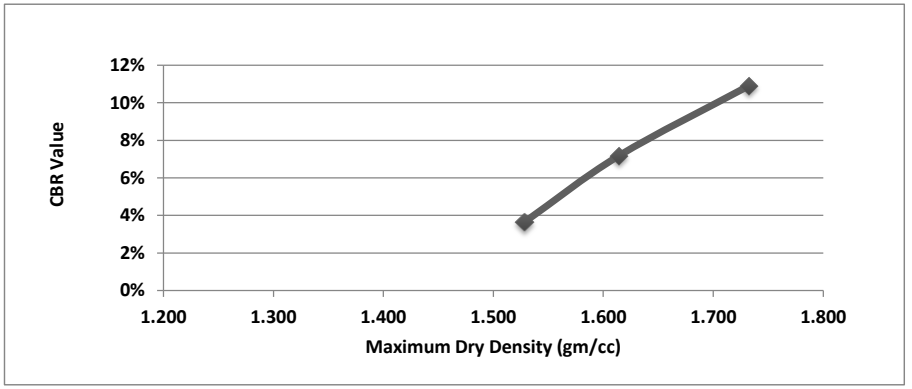
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-04
Depth : 0.50-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.53	1.37	11.45	24.65	0.150	4.5 kg	3.64
30 blows	1.61	1.48	11.45	21.45	0.290		7.18
65 blows	1.73	1.63	11.45	18.66	0.480		10.91



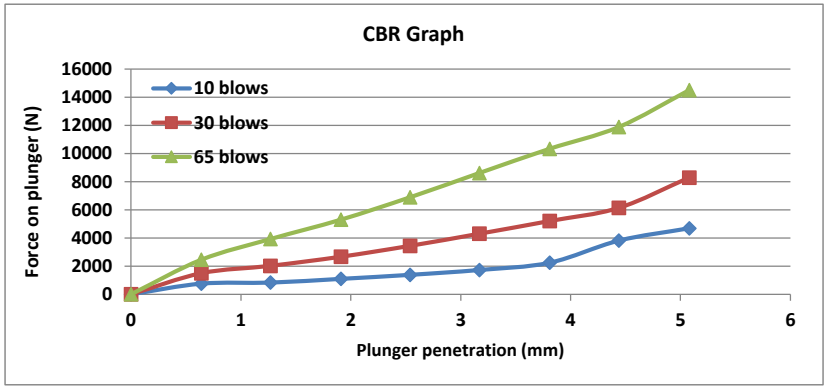


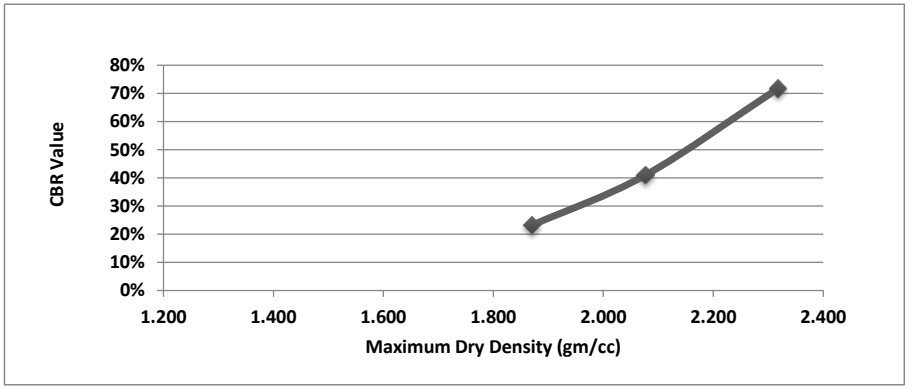
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-05
Depth : 0.15-0.45 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.87	1.77	4.65	10.45	0.000	4.5 kg	23.18
30 blows	2.08	2.00	4.65	8.66	0.000		40.97
65 blows	2.32	2.29	4.65	6.11	0.000		71.66



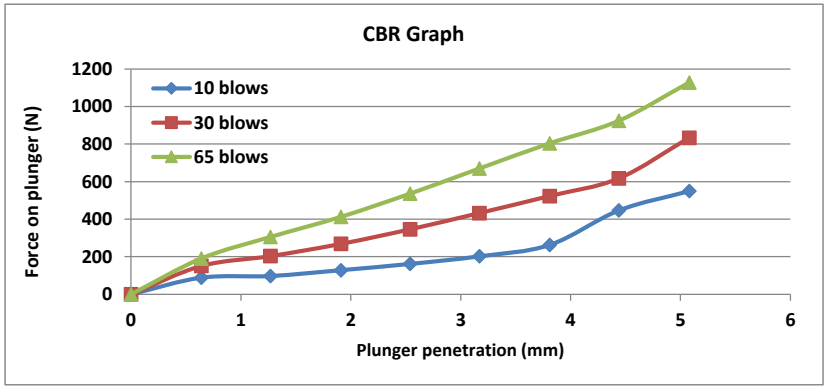


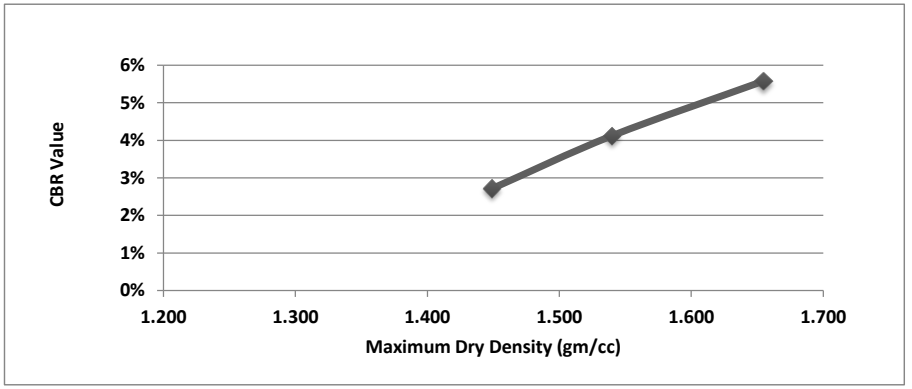
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-05
Depth : 0.45-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.45	1.29	10.90	24.65	0.560	4.5 kg	2.72
30 blows	1.54	1.41	10.90	21.45	0.980		4.12
65 blows	1.65	1.55	10.90	18.66	1.230		5.58



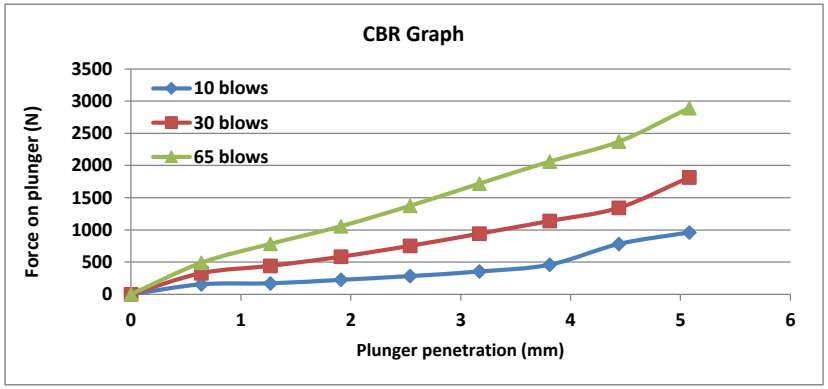


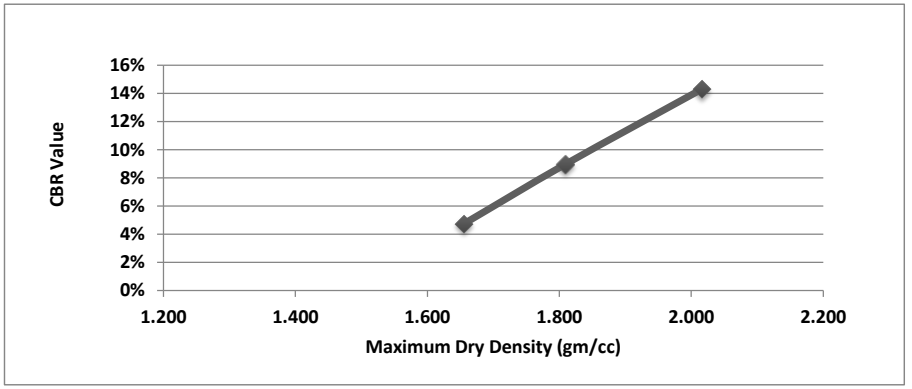
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-06
Depth : 0.45-0.75 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.66	1.52	7.20	16.45	0.120	4.5 kg	4.75
30 blows	1.81	1.73	7.20	12.32	0.220		8.97
65 blows	2.02	1.95	7.20	11.01	0.320		14.30



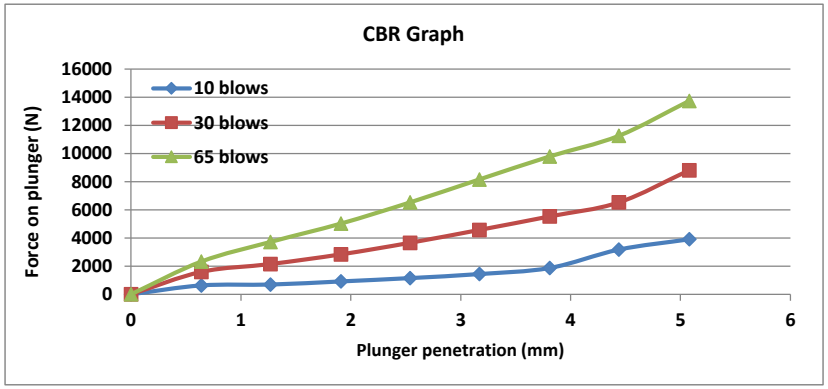


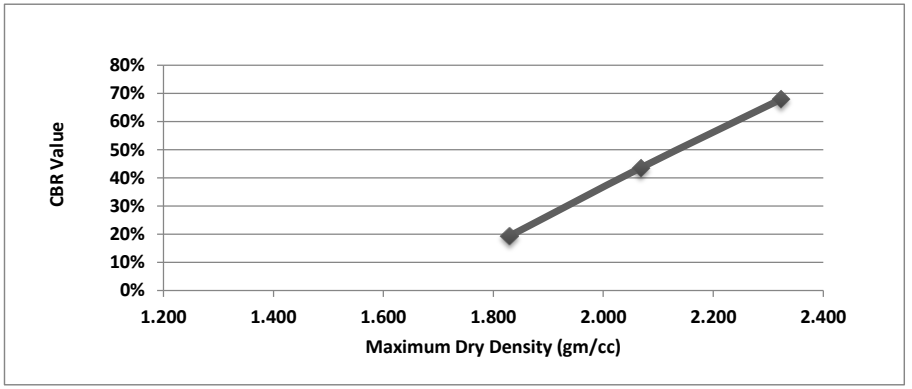
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-07
Depth : 0.2-0.5 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.83	1.74	4.40	9.65	0.000	4.5 kg	19.30
30 blows	2.07	2.01	4.40	7.45	0.000		43.54
65 blows	2.32	2.29	4.40	6.12	0.000		67.88



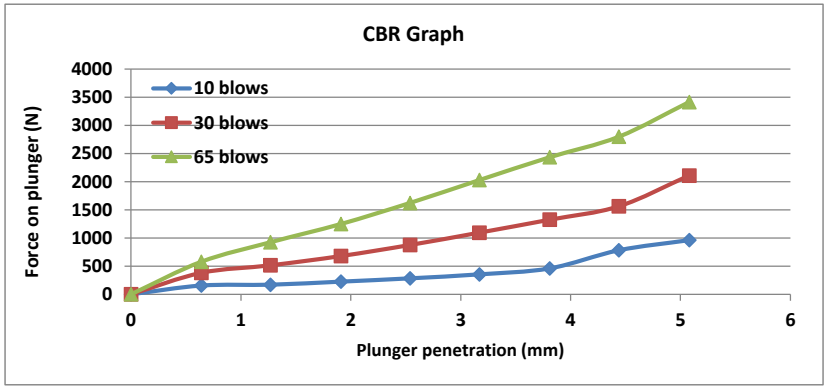


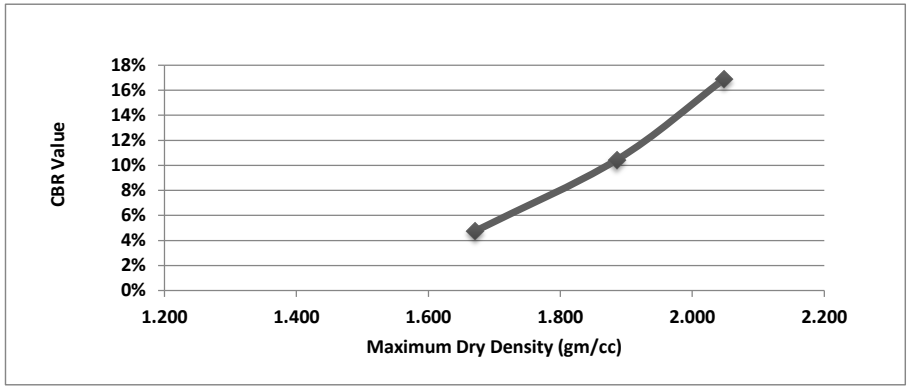
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-07
Depth : 1.0-2.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.67	1.56	7.65	14.98	0.000	4.5 kg	4.75
30 blows	1.89	1.83	7.65	11.05	0.000		10.42
65 blows	2.05	2.00	7.65	10.32	0.000		16.87



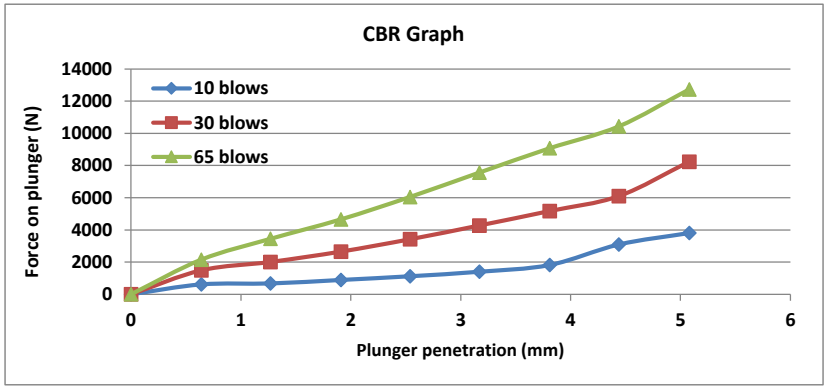


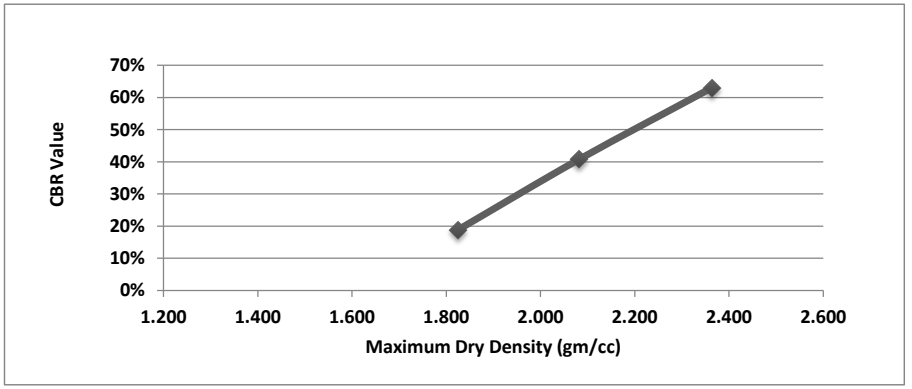
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-11
Depth : 0.12-0.42 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.82	1.72	4.65	10.95	0.000	4.5 kg	18.81
30 blows	2.08	2.01	4.65	8.45	0.000		40.73
65 blows	2.36	2.31	4.65	6.95	0.000		62.94



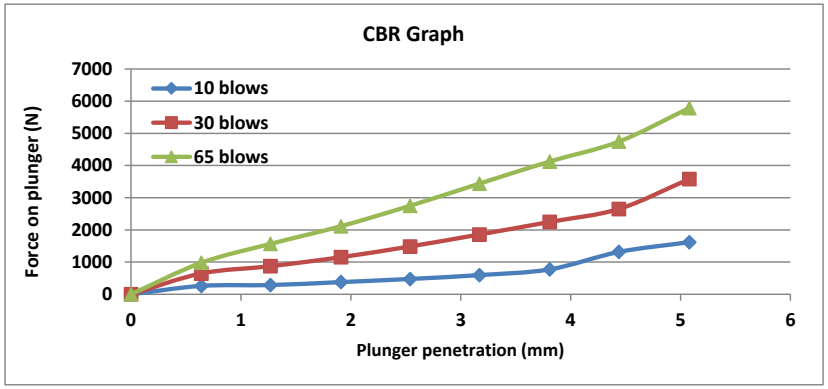


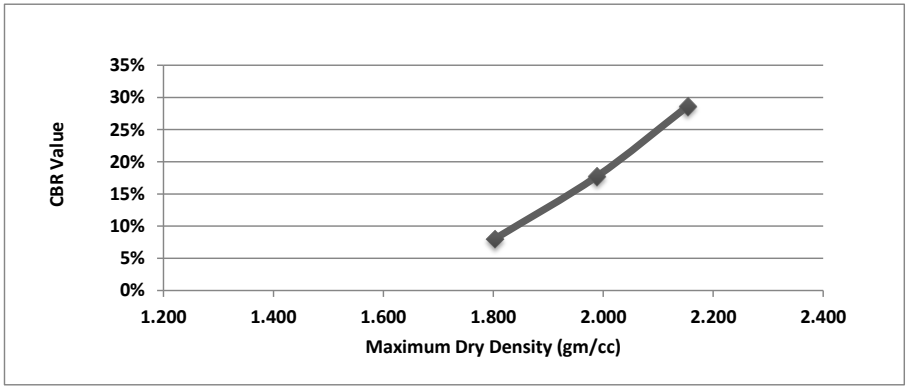
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No. : TP-11
Depth : 0.42-1.0 (m)
Test Type : Three Point Soaked

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (gm/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.80	1.71	5.95	11.50	0.000	4.5 kg	8.00
30 blows	1.99	1.92	5.95	9.45	0.000		17.70
65 blows	2.15	2.13	5.95	7.15	0.000		28.61



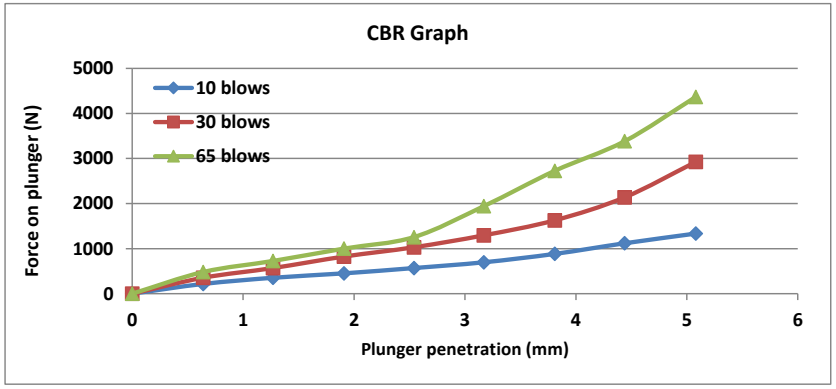


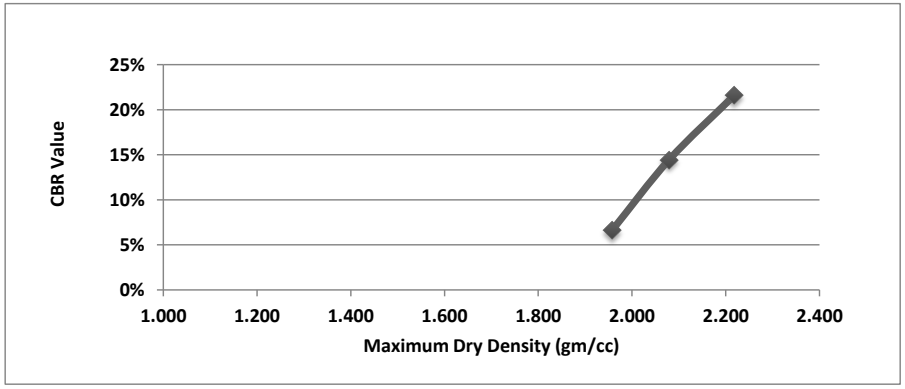
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No.: TP-15
Depth: 0.6-2.0 (m)
Test Type: Three Point Soaked CBR

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (g/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.96	1.81	6.90	15.45	0.000	4.5 kg	6.59
30 blows	2.08	1.97	6.90	12.65	0.000		14.45
65 blows	2.22	2.15	6.90	10.06	0.000		21.58



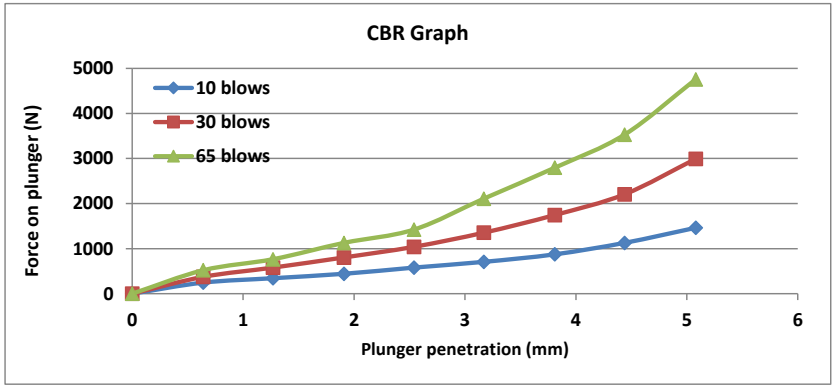


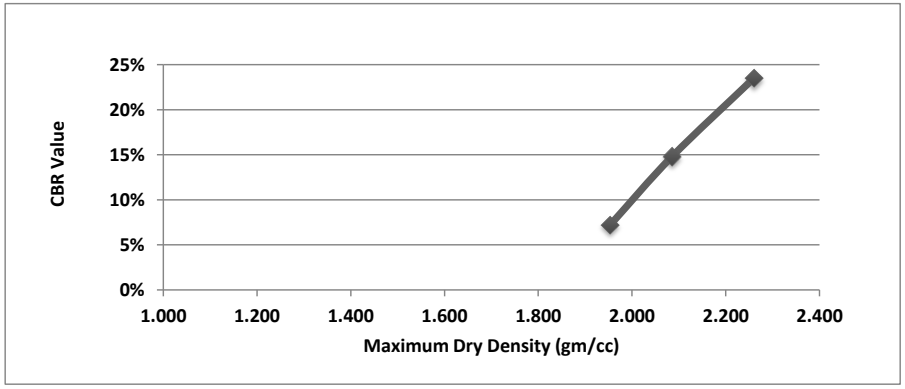
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No.: TP-16
Depth: 0.3-2.0 (m)
Test Type: Three Point Soaked CBR

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (g/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.95	1.82	6.60	14.56	0.000	4.5 kg	7.22
30 blows	2.09	1.99	6.60	11.65	0.000		14.79
65 blows	2.26	2.20	6.60	9.66	0.000		23.52



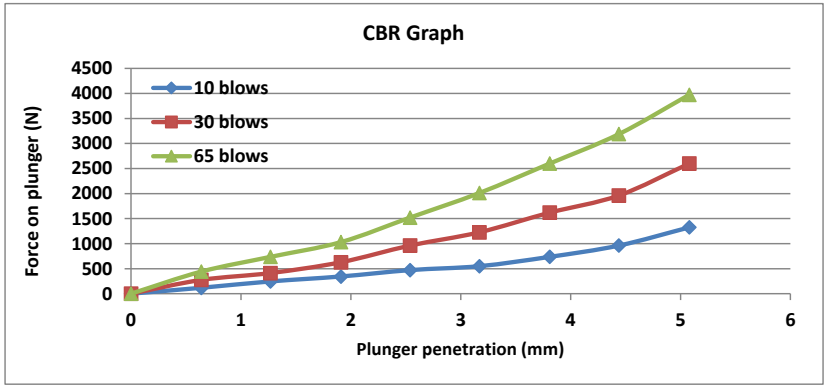


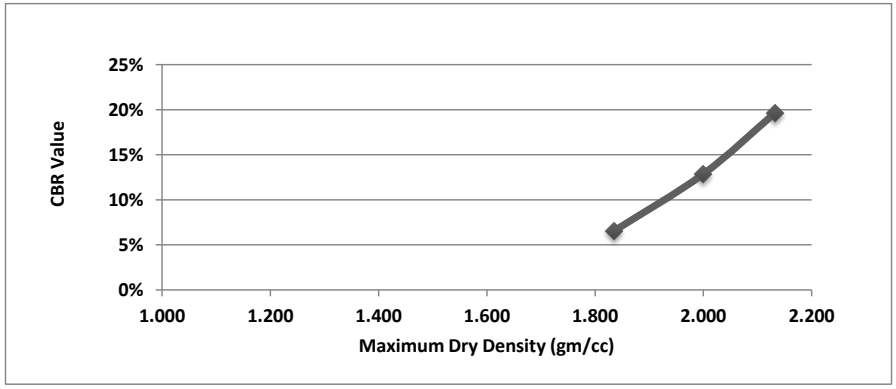
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No.: TP-17
Depth: 0.0-1.5 (m)
Test Type: Three Point Soaked CBR

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (g/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.84	1.71	8.70	16.65	0.000	4.5 kg	6.55
30 blows	2.00	1.90	8.70	14.45	0.000		12.85
65 blows	2.13	2.08	8.70	11.66	0.000		19.64



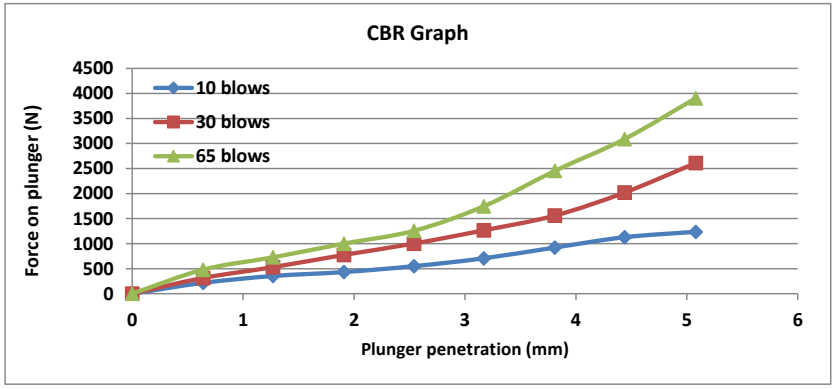


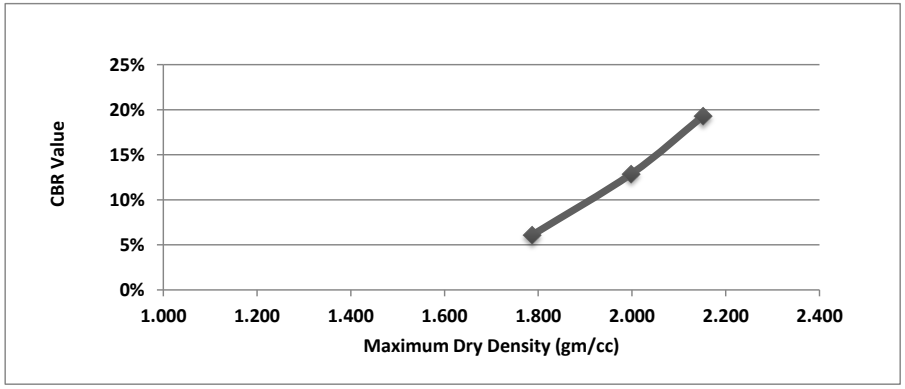
Project: GI for Yellow BRTS Line
Client: Nespak (Pvt.) Ltd.
Job No.: K19-1092-101
Location: Korangi, Karachi

Pit No.: TP-18
Depth: 0.15-2.0 (m)
Test Type: Three Point Soaked CBR

California Bearing Ratio (ASTM D 1883-05)

Identification	Dry Density (g/cm^3)		Water content (%)		Swell (%)	Surcharge amount	CBR (%)
	Before soaking	After soaking	Before soaking	After soaking			
10 blows	1.79	1.66	7.50	15.98	0.000	4.5 kg	6.11
30 blows	2.00	1.91	7.50	12.66	0.000		12.90
65 blows	2.15	2.09	7.50	10.77	0.000		19.30





Appendix E

General Information on Testing Procedures

A. DRILLING, FIELD TESTING & SAMPLING

The field testing program consisted of drilling works, and in-situ testing including Standard Penetration Tests (SPT), collection of soil samples, collection of water samples, rock coring, excavation of test pits and field density test in excavated pits. The following sections describe these activities in further detail.

A.1. DRILLING METHOD

All the boreholes were drilled by using rotary/wash boring method; in this method soil is cut by the constant rotation of various types of bits. Drilling fluid, which is either water or bentonite slurry, is circulated through drilling rods. The returning fluid lifts loosened material. Tricone bit was used for cohesive and granular soils.

The drilling in rock was carried out by double tube core barrels in conjunction with carbide or diamond bit. In a double tube core barrel the outer barrel is rotated by the drill rods, while, the inner barrel, which is mounted on a swivel, does not rotate during the drilling process. The core cut by the coring bit passes into the inner barrel. Core was prevented from dropping out by a steel core catcher it was then extruded and wrapped with waxed bandage tape, to preserve the natural moisture of the recovered core. The cores were stored in a core box and transported to the laboratory for testing. Figure A-1 shows the drilling works in progress.

Details of the boreholes are given in Table A.1.

Table A.1 Details of Boreholes

S. No.	Borehole No.	Borehole Depth (meters)	Water Table depth (meters)	Coordinates
1	BH-01	10	Not Encountered	Easting:317713.3900 Northing:2749930.9115
2	BH-02	20	7.93	Easting:316285.9555 Northing:2749676.2664
3	BH-03	10	Not Encountered	Easting:314672.6281 Northing:2749330.1123
4	BH-04	20	11.5	Easting:314199.3254 Northing:2749234.6492

S. No.	Borehole No.	Borehole Depth (meters)	Water Table depth (meters)	Coordinates
5	BH-05	10	Not Encountered	Easting:313126.6370 Northing:2749014.5956
6	BH-06	20	10.45	Easting:312320.7449 Northing:2748852.1040
7	BH-07	20	9.76	Easting:311519.7886 Northing:2748688.6702
8	BH-08	10	Not Encountered	Easting:310997.5032 Northing:2748583.7502
9	BH-09	20	8.65	Easting:310231.1346 Northing:2748429.1194
10	BH-10	10	Not Encountered	Easting:309527.4475 Northing:2748285.5592
11	BH-11	10	Not Encountered	Easting:308833.6509 Northing:2748146.5982
12	BH-12	20	10.97	Easting:308085.9062 Northing:2747994.3191
13	BH-13	29	0.76	Easting:307101.2876 Northing:2747760.1906
14	BH-14	30	0.91	Easting:306694.9926 Northing:2747677.5705
15	BH-15	30	0.91	Easting:307160.0766 Northing:2747819.2190
16	BH-16	40	0.91	Easting:306792.2257 Northing:2747757.3123
17	BH-17	12	1.52	Easting:305818.7149 Northing:2747619.4863
18	BH-18	18	0.61	Easting:304921.3548 Northing:2748157.8324
19	BH-19	10	5.03	Easting:304058.7409 Northing:2748668.9782
20	BH-20	12	Not Encountered	Easting:303510.0586 Northing:2749158.7743
21	BH-21	10	2.5	Easting:303160.1063 Northing:2750213.1914

S. No.	Borehole No.	Borehole Depth (meters)	Water Table depth (meters)	Coordinates
22	BH-22	10	Not Encountered	Easting:303555.4038 Northing:2750813.7539
23	BH-23	14	Not Encountered	Easting:303349.5211 Northing:2751533.2125
24	BH-24	10	Not Encountered	Easting:319018.1300 Northing:2749521.2500
25	BH-25	10	Not Encountered	Easting:319063.5800 Northing:2749518.85
26	BH-26	11	2.5	Easting:309580.2000 Northing:2746129.3400
27	BH-27	12	2.5	Easting:309537.5000 Northing:2746079.97

Figure A-1 Drilling works in progress

A.2. TEST PITS

Seventeen (17) test pits were excavated up to a maximum depth of 2.0 meters for collection of bulk samples. Filed density tests were carried out in the test pits excavated at the site. Bulk samples were also collected from the test pits and transported to laboratory. Figure A-2 shows the excavated test pit.

Table A-2 Test Pit Details

S. No.	Test Pit No.	Test Pit Depth (meters)	Water Table depth (meters)	Coordinates
1	TP-01	2	Not Encountered	Easting:315845.9719 Northing:2749539.4965
2	TP-02	2	Not Encountered	Easting:314490.0578 Northing:2749265.7051
3	TP-03	2	Not Encountered	Easting:313398.4469 Northing:2749039.8281
4	TP-04	2	Not Encountered	Easting:311809.9317 Northing:2748721.3173
5	TP-05	2	Not Encountered	Easting:310634.1017 Northing:2748479.3777
6	TP-06	2	Not Encountered	Easting:309336.5402 Northing:2748205.6524
7	TP-07	2	Not Encountered	Easting:307917.6323 Northing:2747912.7095
8	TP-09	2	Not Encountered	Easting:306305.7977 Northing:2747599.2977
9	TP-10	1.20	1.20	Easting:305059.6543 Northing:2748059.8175
10	TP-11	1.10	1.10	Easting:304341.6114 Northing:2748473.5889
11	TP-12	1.20	1.20	Easting:303252.4682 Northing:2749880.5053
12	TP-13	2	Not Encountered	Easting:303727.5643 Northing:2750837.0644
13	TP-14	2	Not Encountered	Easting:303585.4524 Northing:2751350.7985

S. No.	Test Pit No.	Test Pit Depth (meters)	Water Table depth (meters)	Coordinates
14	TP-15	1.70	1.70	Easting:319079.0700 Northing:2749545.4600
15	TP-16	1.40	1.40	Easting:319100.3600 Northing:2749481.20
16	TP-17	1.10	1.10	Easting:309513.0800 Northing:2745907.55
17	TP-18	1.50	1.50	Easting:309570.6100 Northing:2746029.400

Figure A-2 Excavated test pit

A.3. FIELD TESTING

Field testing forms a crucial part of the soil investigation process and its results are used in the geotechnical design. Field testing carried out at the site includes Standard Penetration Test (SPT) in the boreholes and Field Density tests (FDT) in test pits. Disturbed soil samples were extracted from all the boreholes with the help of soil sampler. Bulk samples were collected from the test pits for further laboratory testing. Following sections indicate the processes carried out in each of the field tests and sampling.

A.3.1. STANDARD PENETRATION TESTS

The standard penetration tests (SPT) were carried out at interval of 1 meter in the overburden above the bedrock. The standard penetration test was carried out by "Safety" type sliding hammer. Split-spoon sampler was used in cohesive and fine granular soils to conduct SPT.

The standard penetration test was carried out by an assembly of the following parts:

- Drive-weight assembly, consisting of a drive head and a 63.5kg impact hammer, a hammer fall guide and the drop system. The drop mechanism will ensure a constant free fall of 760mm.
- Drive rods connect the drive-weight assembly to the sampler.
- The split spoon sampler was used to carry out the test, along with retrieving disturbed samples.

The base of the borehole was made clean and reasonably undisturbed at the test elevation. Following precautions were taken during the testing sequence:

- The level of water or bentonite slurry was maintained at a sufficient level above the groundwater level, to ensure any entry of water through the bottom of the borehole.
- The casing was not driven below the level at which the test will start.

The test was executed in the following steps:

- The sampler and the drive rods were lowered in the borehole and the hammer assembly added to it.
- The sampler is penetrated over seating drive of 150mm and the numbers of blows are recorded.

- In the same way the sampler is driven over a test drive of 300mm in two increments of 150mm.
- The numbers of blows are recorded during each of the last two increments.
- The test was deemed finished when total number of blows equal to 50 was reached.

The standard penetration test was carried out in accordance with the procedure given in BS 1377-9:1990.

Figure A-3 SPT in progress

A.3.2. FIELD DENSITY TEST

Field density tests were carried out at site for testing in-situ compaction (density) of soil. Field density test were carried out by sand-cone method as per *ASTM D 1556-07*.

A small hole is dug in the soil layer of interest and the soil removed is retained. The volume of the hole is determined by filling the hole with a free flowing sand of known density and the volume is determined. The in-place wet density of the soil is determined by dividing the wet mass of the removed material by the volume of the hole. The water content of the material from the hole is determined and the dry mass of the materials and the in-place dry density are calculated using the wet mass of the soil, the water content and the volume of the hole.

Figure A-3 Field density test in progress

A.4. SAMPLING

Sampling forms an essential part of the geotechnical investigation process and good sampling is essential for proper laboratory testing of samples for determining strength and compressibility characteristics of soil.

Soil samples were extracted from all the boreholes with the help of following tools:

- Disturbed samples through SPT
- Rock core samples through Double Tube Core Barrel

Following section indicates the processes carried out in each of the field tests and sampling.

A.4.1. SPT SAMPLES

Samples were recovered from standard penetration testing. The samples were recovered in split-spoon sampler and then stored in plastic bags. The storage of split-spoon samples in bags ensured retention of natural moisture of the samples which were later tested for gradation, consistency and chemical characteristics.

Figure A-4 Soil sample in SPT split spoon sampler

A.4.2. BULK SAMPLES

Bulk samples were collected from excavated test pits. The samples were stored in plastic bags and transported to the lab. These samples were later tested for gradation, California bearing ratio, and maximum dry density using Proctor test.

A.4.3. ROCK CORE SAMPLES

Rock core samples were collected from the deposits through coring. Unconfined compressive strength of these samples was determined in the laboratory. Figure A-5 shows the rock samples stored in core box.

Figure A-5 Rock core samples in core box

A.4.4. WATER SAMPLES

In order to determine the chemical characteristic of groundwater, water samples were collected from the boreholes. The samples were preserved in airtight bottle & later transported to the testing laboratory. Chemical characteristics of water samples have also been assessed through determination of sulphate content, chloride content, TDS and pH.

B. LABORATORY TESTING

Laboratory testing was carried out on retrieved samples. The following section enlists and gives details of relevant tests carried out on selected samples as required for determining the subsurface conditions and correlating with the information obtained from field testing and sampling.

B.1. GRAIN SIZE ANALYSIS

The purpose of grain size analysis is to determine the sizes of the assemblage of particles that make up the soil. The grain size analysis is conducted in two parts: for particles above the "# 200 US sieve", sieve analysis is carried out by passing the selected soil sample from various sieves. For particles finer than the "# 200 US sieve", hydrometer analysis is carried out. The combined process of determination of the size of particles is termed as the grain size analysis.

The results are appended with the report in Appendix C. Grain size analysis of seventy six (76) soil samples were carried out as per ASTM C-136 & ASTM D-6918.

B.2. LIQUID AND PLASTIC LIMITS

The liquid and plastic limits of soil are parameters that define the state of the soil at different water content levels. The liquid limit is the water content above which the soil goes from solid phase to liquid phase and the plastic limit indicates the water content below which the soil mass makes the transition from a plastic, remould able solid to a brittle mass which cannot be remoulded any more. The difference in the water contents at Liquid and Plastic limits is termed as the plasticity index and it is a measure of the plasticity of the soil under consideration. The samples used for determining the limits are finer than the "#40 US sieve". The limits were determined in accordance with the *ASTM D-4318.*

Liquid and plastic limits of twenty seven (27) samples extracted from boreholes were carried out in accordance with the given procedure.

B.3. NATURAL MOISTURE CONTENT

Natural moisture content is the quantity of water contained in a soil or rock sample. It is the ratio of the weight of water to the weight of solids in a given volume of soil or rock

sample. Natural moisture content of twenty three (23) samples was determined in accordance with *ASTM 2216-05.*

B.4. DENSITY

The weight per unit volume of the solid portion of soil is called particle (dry) density. Whereas, the oven dry weight of a unit volume of soil inclusive of pore spaces is called bulk (wet) density. The bulk density of a soil is always smaller than its particle density. Density of twenty three (23) samples was determined in accordance with the procedure described in *ASTM D 7263-09*.

B.5. UNCONFINED COMPRESSION TEST

Unconfined compressive strength test involves axially loading a cylindrical rock core or undisturbed clay sample to failure. The term unconfined is used because the lateral force on the sample is zero. The unconfined compressive strength test was carried out in accordance with ASTM D-2166 & ASTM D-2938. The strength of the retrieved samples tested came out to be ranging from 0.45 Kg/cm^2 to 44.87 Kg/cm^2. The results of the unconfined compression test are summarized in Appendices.

B.6. DIRECT SHEAR TEST

The direct shear test involves, placing a test sample in a rectangular box having two portions, the top portion can move while the lower portion is fixed. The sample is consolidated under a normal load. Also, double drainage is ensured by placing porous stones on the top and bottom of the sample. Hence, the test may be carried out under drained conditions. The shear strength of a remoulded sample is measured by applying a horizontal force which pushes the top part of rectangular box, the sample is sheared to failure and the normal and shear stresses at the point of failure are noted down. The shear box test (or the direct shear test) suffers from various limitations the most prominent of which is the forced failure plane formed due the configuration of the apparatus; this might result in concealing the actual plane of failure. As, the tests are carried out on disturbed samples and since only the stresses at the point of failure are determined the test results cannot be reliably used in describing the strength characteristics of the ground. The *ASTM D 3080-04* was followed for the performance of static direct simple shear tests.

B.7. CONSOLIDATION TEST

Consolidation is the characteristic of a soil that is associated with the following effects of imposed loading:

- Settlement
- Drainage
- Dissipation of excess pore water pressure

The consolidation characteristic of clays is determined in the oedometer cell. Double drainage path was provided to the sample in the form of porous stones at the top and bottom of the sample. The sample used for the consolidation test is completely saturated and remains submerged in the water throughout the duration of the test. The double drainage allows fast dissipation of excess pore water pressure generated as a result of the imposition of static normal load on the sample. One oedometer test was carried out on clay samples in a front loaded apparatus.

B.8. MODIFIED PROCTOR TEST

This laboratory compaction method is used to determine the relationship between water content and dry unit weight of soils. The test is used to determine Maximum Dry Density (MDD) and Optimum Moisture Content (OMC). The samples were excavated from test pits dug on the site and compacted using standard procedure outlined in ASTM D-1557-12. The maximum dry density came out to be 2.32 gram/cm^3 and the optimum moisture content was found to be 4.65%. The results of the test are summarized in Appendices.

B.9. CALIFORNIA BEARING RATIO (CBR)

California Bearing Ratio (CBR) gives the relative penetration resistance of soil samples which have been compacted in moulds prescribed by the *ASTM D 1883-05*. Bulk soil samples were prepared in accordance with the given standard and tested for three point soaked *CBR* test. CBR on eight (08) soil sample was performed in the laboratory. The results of the test are summarized in *Appendices.*

B.10. ORGANIC CONTENT OF SOIL

The organic content is the ratio, expressed as a percentage, of the mass of organic matter in a given mass of soil to the mass of the dry soil solids. Organic matter

influences many of the physical, chemical and biological properties of soils. It also affects the water holding capacity, nutrient contributions, biological activity, and water and air infiltration rates.

B.11. CHEMICAL TESTS

Sulphate in groundwater or soil can attack concrete placed in the ground or on surface. A reaction takes place between the sulphate and the aluminate compounds present in the cement, causing crystallisation of complex compounds. The expansion, which accompanies crystallisation, induces stresses in the concrete, which results in mechanical disintegration.

In moist conditions, such as exposure to seawater, the presence of chloride ion, Cl^-, presents a serious possibility of the corrosion of the reinforcement. The presence of $Ca(OH)_2$ provides a strong alkaline environment in which a thin film of iron oxide is formed on the metal surface which protects it against corrosion. However, if the concrete is permeable to the extent that the soluble chlorides can reach up to the reinforcing steel, then in the presence of water and oxygen, the corrosion of the reinforcement will take place. Rust occupies more volume than the original steel, and hence the ensuing expansion of concrete, results in cracking and spalling.

Due to adverse effect of sulphates and chlorides on the quality of concrete it is essential to conduct chemical tests on soil and groundwater. This helps in quantifying the expected exposure of concrete to these chemicals and in devising precautionary measures to ensure integrity of concrete. The following chemical tests were carried out on groundwater samples:

- Total dissolved solids
- Chloride content
- Sulphate content
- pH

Chemical tests were carried out in accordance with *ASTM C 1580-09, and D 4972-01*. The selection of cement for underground concreting and is discussed in *Chapter 4*.

Table B.1 ACI standards for concrete for sulphate exposure

Sulphate Exposure	Water Soluble Sulphates in Soil (%)	Sulphate in Water (mg/L)	Cement Type
Negligible	0.00-0.10	0- 150	OPC
Moderate	0.10-0.20	150- 1500	Type II
Severe	0.20-2.00	1500-10000	Type V
Very Severe	Over 2.00	Over 10000	Type V plus pozzolan

Appendix F

Calculations for Pile Foundation

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-12

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	cohesionless	0.76	1	18	9.00	32	-	-	-	-	-	32	0.62	0.470	2.0	3	3
3-4	cohesionless	0.76	1	18	27.00	32	-	-	-	-	-	32	0.62	0.470	2.0	9	13
4-5	cohesionless	0.76	1	18	45.00	32	-	-	-	-	-	32	0.62	0.470	2.0	16	28
5-6	cohesionless	0.76	1	19	63.50	35	-	-	-	-	-	35	0.70	0.426	2.0	23	51
6-7	cohesionless	0.76	1	16	81.00	25	-	-	-	-	-	25	0.47	0.577	2.0	26	77
7-8	cohesive	0.76	1	18	98.00	-	125	-	0.5	-	-	-	-	-	2.0	75	152
8-9	cohesionless	0.76	1	18.5	116.25	33	-	-	-	-	-	33	0.65	0.455	2.0	41	193
9-10	cohesionless	0.76	1	18.5	134.75	33	-	-	-	-	-	33	0.65	0.455	2.0	48	240
10-11	cohesive	0.76	1	8	148.00	-	64	-	0.5	-	-	-	-	-	2.0	38	278
11-12	cohesive	0.76	1	8	156.00	-	64	-	0.5	-	-	-	-	-	2.0	38	317
12-13	cohesionless	0.76	1	9	164.50	35	-	-	-	-	-	35	0.70	0.426	2.0	59	375
13-14	cohesionless	0.76	1	9	173.50	35	-	-	-	-	-	35	0.70	0.426	2.0	62	437
14-15	cohesionless	0.76	1	9	182.50	35	-	-	-	-	-	35	0.70	0.426	2.0	65	502
15-16	cohesive	0.76	1	8.5	191.25	-	150	-	0.5	-	-	-	-	-	2.0	90	592
16-17	cohesive	0.76	1	8.5	199.75	-	150	-	0.5	-	-	-	-	-	2.0	90	681
17-18	cohesionless	0.76	1	9	208.50	35	-	-	-	-	-	35	0.70	0.426	2.0	74	755
18-19	cohesive	0.76	1	8.5	217.25	-	150	-	0.5	-	-	-	-	-	2.0	90	845
19-20	cohesive	0.76	1	8.5	225.75	-	150	-	0.5	-	-	-	-	-	2.0	90	935

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-12

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	cohesionless	1.00	1	18	9.00	32	-	-	-	-	-	32	0.62	0.470	2.0	4	4
3-4	cohesionless	1.00	1	18	27.00	32	-	-	-	-	-	32	0.62	0.470	2.0	12	17
4-5	cohesionless	1.00	1	18	45.00	32	-	-	-	-	-	32	0.62	0.470	2.0	21	37
5-6	cohesionless	1.00	1	19	63.50	35	-	-	-	-	-	35	0.70	0.426	2.0	30	67
6-7	cohesionless	1.00	1	16	81.00	25	-	-	-	-	-	25	0.47	0.577	2.0	34	101
7-8	cohesive	1.00	1	18	98.00	-	125	-	0.5	-	-	-	-	-	2.0	98	200
8-9	cohesionless	1.00	1	18.5	116.25	33	-	-	-	-	-	33	0.65	0.455	2.0	54	254
9-10	cohesionless	1.00	1	18.5	134.75	33	-	-	-	-	-	33	0.65	0.455	2.0	63	316
10-11	cohesive	1.00	1	8	148.00	-	64	-	0.5	-	-	-	-	-	2.0	50	366
11-12	cohesive	1.00	1	8	156.00	-	64	-	0.5	-	-	-	-	-	2.0	50	417
12-13	cohesionless	1.00	1	9	164.50	35	-	-	-	-	-	35	0.70	0.426	2.0	77	494
13-14	cohesionless	1.00	1	9	173.50	35	-	-	-	-	-	35	0.70	0.426	2.0	81	575
14-15	cohesionless	1.00	1	9	182.50	35	-	-	-	-	-	35	0.70	0.426	2.0	86	661
15-16	cohesive	1.00	1	8.5	191.25	-	150	-	0.5	-	-	-	-	-	2.0	118	778
16-17	cohesive	1.00	1	8.5	199.75	-	150	-	0.5	-	-	-	-	-	2.0	118	896
17-18	cohesionless	1.00	1	9	208.50	35	-	-	-	-	-	35	0.70	0.426	2.0	98	994
18-19	cohesive	1.00	1	8.5	217.25	-	150	-	0.5	-	-	-	-	-	2.0	118	1112
19-20	cohesive	1.00	1	8.5	225.75	-	150	-	0.5	-	-	-	-	-	2.0	118	1230

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-12

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	cohesionless	1.20	1	18	9.00	32	-	-	-	-	-	32	0.62	0.470	2.0	5	5
3-4	cohesionless	1.20	1	18	27.00	32	-	-	-	-	-	32	0.62	0.470	2.0	15	20
4-5	cohesionless	1.20	1	18	45.00	32	-	-	-	-	-	32	0.62	0.470	2.0	25	45
5-6	cohesionless	1.20	1	19	63.50	35	-	-	-	-	-	35	0.70	0.426	2.0	36	81
6-7	cohesionless	1.20	1	16	81.00	25	-	-	-	-	-	25	0.47	0.577	2.0	41	122
7-8	cohesive	1.20	1	18	98.00	-	125	-	0.5	-	-	-	-	-	2.0	118	239
8-9	cohesionless	1.20	1	18.5	116.25	33	-	-	-	-	-	33	0.65	0.455	2.0	65	304
9-10	cohesionless	1.20	1	18.5	134.75	33	-	-	-	-	-	33	0.65	0.455	2.0	75	379
10-11	cohesive	1.20	1	8	148.00	-	64	-	0.5	-	-	-	-	-	2.0	60	440
11-12	cohesive	1.20	1	8	156.00	-	64	-	0.5	-	-	-	-	-	2.0	60	500
12-13	cohesionless	1.20	1	9	164.50	35	-	-	-	-	-	35	0.70	0.426	2.0	93	592
13-14	cohesionless	1.20	1	9	173.50	35	-	-	-	-	-	35	0.70	0.426	2.0	98	690
14-15	cohesionless	1.20	1	9	182.50	35	-	-	-	-	-	35	0.70	0.426	2.0	103	793
15-16	cohesive	1.20	1	8.5	191.25	-	150	-	0.5	-	-	-	-	-	2.0	141	934
16-17	cohesive	1.20	1	8.5	199.75	-	150	-	0.5	-	-	-	-	-	2.0	141	1076
17-18	cohesionless	1.20	1	9	208.50	35	-	-	-	-	-	35	0.70	0.426	2.0	117	1193
18-19	cohesive	1.20	1	8.5	217.25	-	150	-	0.5	-	-	-	-	-	2.0	141	1334
19-20	cohesive	1.20	1	8.5	225.75	-	150	-	0.5	-	-	-	-	-	2.0	141	1476

ALLOWABLE END BEARING RESISTANCE :

BH-12

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Nc	Nq	Overburden pressure (kPa)	Cohesion (kPa)	FOS	Q_{END} (kN)	Qend + Qskin (kN)
Cohesionless	760.0	13.0	-	40.0	164.5	-	2.0	1492	1867
Cohesionless	760.0	17.0	-	40.0	199.8	-	2.0	1811	2493
Cohesionless	1000.0	13.0	-	40.0	164.5	-	2.0	2583	3076
Cohesionless	1000.0	17.0	-	40.0	199.8	-	2.0	3136	4032
Cohesionless	1200.0	13.0	-	40.0	164.5	-	2.0	3719	4312
Cohesionless	1200.0	17.0	-	40.0	199.8	-	2.0	4516	5592

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-4	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-5	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-6	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-7	cohesionless	0.76	1	8	4.00	32	-	-	-	-	-	32	0.62	0.470	2.0	1	1
7-8	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-9	cohesive	0.76	1	7.5	11.75	-	40	-	0.5	-	-	-	-	-	2.0	24	25
9-10	cohesive	0.76	1	7.5	19.25	-	40	-	0.5	-	-	-	-	-	2.0	24	49
10-11	cohesionless	0.76	1	8.5	27.25	35	-	-	-	-	-	35	0.70	0.426	2.0	10	59
11-12	cohesionless	0.76	1	8.5	35.75	35	-	-	-	-	-	35	0.70	0.426	2.0	13	72
12-13	cohesionless	0.76	1	8.5	44.25	35	-	-	-	-	-	35	0.70	0.426	2.0	16	87
13-14	cohesive	0.76	1	8	52.50	-	150	-	0.5	-	-	-	-	-	2.0	90	177
14-15	cohesive	0.76	1	8	60.50	-	150	-	0.5	-	-	-	-	-	2.0	90	267
15-16	cohesive	0.76	1	8	68.50	-	150	-	0.5	-	-	-	-	-	2.0	90	356
16-17	cohesive	0.76	1	8	76.50	-	150	-	0.5	-	-	-	-	-	2.0	90	446
17-18	cohesive	0.76	1	8	84.50	-	150	-	0.5	-	-	-	-	-	2.0	90	535
18-19	cohesive	0.76	1	8	92.50	-	150	-	0.5	-	-	-	-	-	2.0	90	625
19-20	cohesive	0.76	1	8	100.50	-	150	-	0.5	-	-	-	-	-	2.0	90	714
20-21	cohesionless	0.76	1	8.5	108.75	36	-	-	-	-	-	36	0.73	0.412	2.0	39	753

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
21-22	cohesionless	0.76	1	8.5	117.25	36	-	-	-	-	-	36	0.73	0.412	2.0	42	795
22-23	cohesionless	0.76	1	8.5	125.75	36	-	-	-	-	-	36	0.73	0.412	2.0	45	840
23-24	cohesionless	0.76	1	8.5	134.25	36	-	-	-	-	-	36	0.73	0.412	2.0	48	888
24-25	cohesionless	0.76	1	8.5	142.75	36	-	-	-	-	-	36	0.73	0.412	2.0	51	939
25-26	cohesionless	0.76	1	8.5	151.25	36	-	-	-	-	-	36	0.73	0.412	2.0	54	993
26-27	cohesionless	0.76	1	8.5	159.75	36	-	-	-	-	-	36	0.73	0.412	2.0	57	1050
27-28	cohesionless	0.76	1	8.5	168.25	36	-	-	-	-	-	36	0.73	0.412	2.0	60	1110
28-29	cohesionless	0.76	1	8.5	176.75	36	-	-	-	-	-	36	0.73	0.412	2.0	63	1173
29-30	cohesionless	0.76	1	8.5	185.25	36	-	-	-	-	-	36	0.73	0.412	2.0	66	1240

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-4	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-5	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-6	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-7	cohesionless	1.00	1	8	4.00	32	-	-	-	-	-	32	0.62	0.470	2.0	2	2
7-8	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-9	cohesive	1.00	1	7.5	11.75	-	40	-	0.5	-	-	-	-	-	2.0	31	33
9-10	cohesive	1.00	1	7.5	19.25	-	40	-	0.5	-	-	-	-	-	2.0	31	65
10-11	cohesionless	1.00	1	8.5	27.25	35	-	-	-	-	-	35	0.70	0.426	2.0	13	77
11-12	cohesionless	1.00	1	8.5	35.75	35	-	-	-	-	-	35	0.70	0.426	2.0	17	94
12-13	cohesionless	1.00	1	8.5	44.25	35	-	-	-	-	-	35	0.70	0.426	2.0	21	115
13-14	cohesive	1.00	1	8	52.50	-	150	-	0.5	-	-	-	-	-	2.0	118	233
14-15	cohesive	1.00	1	8	60.50	-	150	-	0.5	-	-	-	-	-	2.0	118	351
15-16	cohesive	1.00	1	8	68.50	-	150	-	0.5	-	-	-	-	-	2.0	118	469
16-17	cohesive	1.00	1	8	76.50	-	150	-	0.5	-	-	-	-	-	2.0	118	586
17-18	cohesive	1.00	1	8	84.50	-	150	-	0.5	-	-	-	-	-	2.0	118	704
18-19	cohesive	1.00	1	8	92.50	-	150	-	0.5	-	-	-	-	-	2.0	118	822
19-20	cohesive	1.00	1	8	100.50	-	150	-	0.5	-	-	-	-	-	2.0	118	940
20-21	cohesionless	1.00	1	8.5	108.75	36	-	-	-	-	-	36	0.73	0.412	2.0	51	991

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
21-22	cohesionless	1.00	1	8.5	117.25	36	-	-	-	-	-	36	0.73	0.412	2.0	55	1046
22-23	cohesionless	1.00	1	8.5	125.75	36	-	-	-	-	-	36	0.73	0.412	2.0	59	1105
23-24	cohesionless	1.00	1	8.5	134.25	36	-	-	-	-	-	36	0.73	0.412	2.0	63	1168
24-25	cohesionless	1.00	1	8.5	142.75	36	-	-	-	-	-	36	0.73	0.412	2.0	67	1236
25-26	cohesionless	1.00	1	8.5	151.25	36	-	-	-	-	-	36	0.73	0.412	2.0	71	1307
26-27	cohesionless	1.00	1	8.5	159.75	36	-	-	-	-	-	36	0.73	0.412	2.0	75	1382
27-28	cohesionless	1.00	1	8.5	168.25	36	-	-	-	-	-	36	0.73	0.412	2.0	79	1461
28-29	cohesionless	1.00	1	8.5	176.75	36	-	-	-	-	-	36	0.73	0.412	2.0	83	1544
29-30	cohesionless	1.00	1	8.5	185.25	36	-	-	-	-	-	36	0.73	0.412	2.0	87	1631

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-4	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-5	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-6	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-7	cohesionless	1.20	1	8	4.00	32	-	-	-	-	-	32	0.62	0.470	2.0	2	2
7-8	Liquefiable Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-9	cohesive	1.20	1	7.5	11.75	-	40	-	0.5	-	-	-	-	-	2.0	38	40
9-10	cohesive	1.20	1	7.5	19.25	-	40	-	0.5	-	-	-	-	-	2.0	38	78
10-11	cohesionless	1.20	1	8.5	27.25	35	-	-	-	-	-	35	0.70	0.426	2.0	15	93
11-12	cohesionless	1.20	1	8.5	35.75	35	-	-	-	-	-	35	0.70	0.426	2.0	20	113
12-13	cohesionless	1.20	1	8.5	44.25	35	-	-	-	-	-	35	0.70	0.426	2.0	25	138
13-14	cohesive	1.20	1	8	52.50	-	150	-	0.5	-	-	-	-	-	2.0	141	279
14-15	cohesive	1.20	1	8	60.50	-	150	-	0.5	-	-	-	-	-	2.0	141	421
15-16	cohesive	1.20	1	8	68.50	-	150	-	0.5	-	-	-	-	-	2.0	141	562
16-17	cohesive	1.20	1	8	76.50	-	150	-	0.5	-	-	-	-	-	2.0	141	704
17-18	cohesive	1.20	1	8	84.50	-	150	-	0.5	-	-	-	-	-	2.0	141	845
18-19	cohesive	1.20	1	8	92.50	-	150	-	0.5	-	-	-	-	-	2.0	141	987
19-20	cohesive	1.20	1	8	100.50	-	150	-	0.5	-	-	-	-	-	2.0	141	1128
20-21	cohesionless	1.20	1	8.5	108.75	36	-	-	-	-	-	36	0.73	0.412	2.0	61	1189

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-13, BH-14, BH-15 & BH-16

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
21-22	cohesionless	1.20	1	8.5	117.25	36	-	-	-	-	-	36	0.73	0.412	2.0	66	1255
22-23	cohesionless	1.20	1	8.5	125.75	36	-	-	-	-	-	36	0.73	0.412	2.0	71	1326
23-24	cohesionless	1.20	1	8.5	134.25	36	-	-	-	-	-	36	0.73	0.412	2.0	76	1402
24-25	cohesionless	1.20	1	8.5	142.75	36	-	-	-	-	-	36	0.73	0.412	2.0	81	1483
25-26	cohesionless	1.20	1	8.5	151.25	36	-	-	-	-	-	36	0.73	0.412	2.0	85	1568
26-27	cohesionless	1.20	1	8.5	159.75	36	-	-	-	-	-	36	0.73	0.412	2.0	90	1658
27-28	cohesionless	1.20	1	8.5	168.25	36	-	-	-	-	-	36	0.73	0.412	2.0	95	1753
28-29	cohesionless	1.20	1	8.5	176.75	36	-	-	-	-	-	36	0.73	0.412	2.0	100	1853
29-30	cohesionless	1.20	1	8.5	185.25	36	-	-	-	-	-	36	0.73	0.412	2.0	104	1957

ALLOWABLE END BEARING RESISTANCE :
BH-13, BH-14, BH-15 & BH-16

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Nc	Nq	Overburden pressure (kPa)	Cohesion (kPa)	FOS	Q_{END} (kN)	Qend + Qskin (kN)
Cohesionless	760.0	20.0	-	40.0	100.5	-	2.0	911	1626
Cohesionless	760.0	25.0	-	40.0	142.8	-	2.0	1295	2234
Cohesionless	1000.0	20.0	-	40.0	100.5	-	2.0	1578	2518
Cohesionless	1000.0	25.0	-	40.0	142.8	-	2.0	2241	3477
Cohesionless	1200.0	20.0	-	40.0	100.5	-	2.0	2272	3400
Cohesionless	1200.0	25.0	-	40.0	142.8	-	2.0	3227	4710

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-17

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	0.76	1	8	4.00	33	-	-	-	-	-	33	0.65	0.455	2.0	1	1
2-3	cohesionless	0.76	1	8	12.00	33	-	-	-	-	-	33	0.65	0.455	2.0	4	6
3-4	cohesive	0.76	1	6.5	19.25	-	15	-	0.5	-	-	-	-	-	2.0	9	15
4-5	cohesive	0.76	1	6.5	25.75	-	15	-	0.5	-	-	-	-	-	2.0	9	24
5-6	cohesive	0.76	1	6.5	32.25	-	15	-	0.5	-	-	-	-	-	2.0	9	33
6-7	cohesive	0.76	1	6.5	38.75	-	15	-	0.5	-	-	-	-	-	2.0	9	41
7-8	cohesive	0.76	1	6.5	45.25	-	15	-	0.5	-	-	-	-	-	2.0	9	50
8-9	cohesive	0.76	1	6.5	51.75	-	15	-	0.5	-	-	-	-	-	2.0	9	59
9-10	cohesive	0.76	1	6.5	58.25	-	15	-	0.5	-	-	-	-	-	2.0	9	68
10-11	cohesive	0.76	1	8	65.50	-	150	-	0.5	-	-	-	-	-	2.0	90	158
11-12	cohesionless	0.76	1	9	74.00	35	-	-	-	-	-	35	0.70	0.426	2.0	26	184

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-17

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	1.00	1	8	4.00	33	-	-	-	-	-	33	0.65	0.455	2.0	2	2
2-3	cohesionless	1.00	1	8	12.00	33	-	-	-	-	-	33	0.65	0.455	2.0	6	7
3-4	cohesive	1.00	1	6.5	19.25	-	15	-	0.5	-	-	-	-	-	2.0	12	19
4-5	cohesive	1.00	1	6.5	25.75	-	15	-	0.5	-	-	-	-	-	2.0	12	31
5-6	cohesive	1.00	1	6.5	32.25	-	15	-	0.5	-	-	-	-	-	2.0	12	43
6-7	cohesive	1.00	1	6.5	38.75	-	15	-	0.5	-	-	-	-	-	2.0	12	55
7-8	cohesive	1.00	1	6.5	45.25	-	15	-	0.5	-	-	-	-	-	2.0	12	66
8-9	cohesive	1.00	1	6.5	51.75	-	15	-	0.5	-	-	-	-	-	2.0	12	78
9-10	cohesive	1.00	1	6.5	58.25	-	15	-	0.5	-	-	-	-	-	2.0	12	90
10-11	cohesive	1.00	1	8	65.50	-	150	-	0.5	-	-	-	-	-	2.0	118	208
11-12	cohesionless	1.00	1	9	74.00	35	-	-	-	-	-	35	0.70	0.426	2.0	35	242

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-17

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	1.20	1	8	4.00	33	-	-	-	-	-	33	0.65	0.455	2.0	2	2
2-3	cohesionless	1.20	1	8	12.00	33	-	-	-	-	-	33	0.65	0.455	2.0	7	9
3-4	cohesive	1.20	1	6.5	19.25	-	15	-	0.5	-	-	-	-	-	2.0	14	23
4-5	cohesive	1.20	1	6.5	25.75	-	15	-	0.5	-	-	-	-	-	2.0	14	37
5-6	cohesive	1.20	1	6.5	32.25	-	15	-	0.5	-	-	-	-	-	2.0	14	51
6-7	cohesive	1.20	1	6.5	38.75	-	15	-	0.5	-	-	-	-	-	2.0	14	65
7-8	cohesive	1.20	1	6.5	45.25	-	15	-	0.5	-	-	-	-	-	2.0	14	80
8-9	cohesive	1.20	1	6.5	51.75	-	15	-	0.5	-	-	-	-	-	2.0	14	94
9-10	cohesive	1.20	1	6.5	58.25	-	15	-	0.5	-	-	-	-	-	2.0	14	108
10-11	cohesive	1.20	1	8	65.50	-	150	-	0.5	-	-	-	-	-	2.0	141	249
11-12	cohesionless	1.20	1	9	74.00	35	-	-	-	-	-	35	0.70	0.426	2.0	42	291

ALLOWABLE END BEARING RESISTANCE :
BH-17

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Nc	Nq	Overburden pressure (kPa)	Cohesion (kPa)	FOS	Q_{END} (kN)	Qend + Qskin (kN)
Cohesionless	760.0	12.0	-	40.0	74.0	-	2.0	671	855
Cohesionless	1000.0	12.0	-	40.0	74.0	-	2.0	1162	1404
Cohesionless	1200.0	12.0	-	40.0	74.0	-	2.0	1673	1964

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-18

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesive	0.76	1	7	3.50	-	20	-	0.5	-	-	-	-	-	2.0	12	12
2-3	cohesive	0.76	1	7	10.50	-	20	-	0.5	-	-	-	-	-	2.0	12	24
3-4	cohesive	0.76	1	7	17.50	-	20	-	0.5	-	-	-	-	-	2.0	12	36
4-5	cohesive	0.76	1	7	24.50	-	20	-	0.5	-	-	-	-	-	2.0	12	48
5-6	cohesive	0.76	1	6.5	31.25	-	10	-	0.5	-	-	-	-	-	2.0	6	54
6-7	cohesive	0.76	1	6.5	37.75	-	10	-	0.5	-	-	-	-	-	2.0	6	60
7-8	cohesive	0.76	1	6.5	44.25	-	10	-	0.5	-	-	-	-	-	2.0	6	66
8-9	Rock	0.76	1	21	58.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	484
9-10	Rock	0.76	1	21	79.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	902
10-11	Rock	0.76	1	21	100.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	1320
11-12	Rock	0.76	1	21	121.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	1738
12-13	Rock	0.76	1	21	142.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	2156
13-14	Rock	0.76	1	21	163.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	2574
14-15	Rock	0.76	1	21	184.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	2992
15-16	Rock	0.76	1	21	205.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	3410
16-17	Rock	0.76	1	21	226.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	3828
17-18	Rock	0.76	1	21	247.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	418	4246

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-18

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesive	1.00	1	7	3.50	-	20	-	0.5	-	-	-	-	-	2.0	16	16
2-3	cohesive	1.00	1	7	10.50	-	20	-	0.5	-	-	-	-	-	2.0	16	31
3-4	cohesive	1.00	1	7	17.50	-	20	-	0.5	-	-	-	-	-	2.0	16	47
4-5	cohesive	1.00	1	7	24.50	-	20	-	0.5	-	-	-	-	-	2.0	16	63
5-6	cohesive	1.00	1	6.5	31.25	-	10	-	0.5	-	-	-	-	-	2.0	8	71
6-7	cohesive	1.00	1	6.5	37.75	-	10	-	0.5	-	-	-	-	-	2.0	8	79
7-8	cohesive	1.00	1	6.5	44.25	-	10	-	0.5	-	-	-	-	-	2.0	8	86
8-9	Rock	1.00	1	21	58.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	636
9-10	Rock	1.00	1	21	79.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	1186
10-11	Rock	1.00	1	21	100.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	1736
11-12	Rock	1.00	1	21	121.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	2286
12-13	Rock	1.00	1	21	142.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	2836
13-14	Rock	1.00	1	21	163.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	3386
14-15	Rock	1.00	1	21	184.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	3936
15-16	Rock	1.00	1	21	205.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	4486
16-17	Rock	1.00	1	21	226.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	5036
17-18	Rock	1.00	1	21	247.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	550	5586

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-18

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesive	1.20	1	7	3.50	-	20	-	0.5	-	-	-	-	-	2.0	19	19
2-3	cohesive	1.20	1	7	10.50	-	20	-	0.5	-	-	-	-	-	2.0	19	38
3-4	cohesive	1.20	1	7	17.50	-	20	-	0.5	-	-	-	-	-	2.0	19	57
4-5	cohesive	1.20	1	7	24.50	-	20	-	0.5	-	-	-	-	-	2.0	19	75
5-6	cohesive	1.20	1	6.5	31.25	-	10	-	0.5	-	-	-	-	-	2.0	9	85
6-7	cohesive	1.20	1	6.5	37.75	-	10	-	0.5	-	-	-	-	-	2.0	9	94
7-8	cohesive	1.20	1	6.5	44.25	-	10	-	0.5	-	-	-	-	-	2.0	9	104
8-9	Rock	1.20	1	21	58.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	764
9-10	Rock	1.20	1	21	79.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	1424
10-11	Rock	1.20	1	21	100.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	2084
11-12	Rock	1.20	1	21	121.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	2744
12-13	Rock	1.20	1	21	142.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	3404
13-14	Rock	1.20	1	21	163.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	4064
14-15	Rock	1.20	1	21	184.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	4724
15-16	Rock	1.20	1	21	205.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	5384
16-17	Rock	1.20	1	21	226.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	6044
17-18	Rock	1.20	1	21	247.00	-	-	1000	-	0.5	0.7	-	-	-	2.0	660	6704

ALLOWABLE END BEARING RESISTANCE :
BH-18

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Φ	NΦ	qc (kPa)	FOS	Q_{END} (kN)	Qend + Qskin (kN)
Rock	760.0	15.0	40.0	4.6	1000.0	3.0	1386	4378
Rock	760.0	18.0	40.0	4.6	1000.0	3.0	1386	5632
Rock	1000.0	15.0	40.0	4.6	1000.0	3.0	2400	6336
Rock	1000.0	18.0	40.0	4.6	1000.0	3.0	2400	7986
Rock	1200.0	15.0	40.0	4.6	1000.0	3.0	3455	8179
Rock	1200.0	18.0	40.0	4.6	1000.0	3.0	3455	10159

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-23

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	FILL	0.76	1	0.0	0.0	0	-	-	-	-	-	0	0.00	1.000	2.0	0	0
1-2	Cohesionless	0.76	1	17.0	8.5	29	-	-	-	-	-	29	0.55	0.515	2.0	3	3
2-3	Cohesive	0.76	1	18.0	26.0	-	125	-	0.5	-	-	-	-	-	2.0	75	78
3-4	Cohesive	0.76	1	18.0	44.0	-	200	-	0.5	-	-	-	-	-	2.0	119	197
4-5	Cohesive	0.76	1	18.0	62.0	-	200	-	0.5	-	-	-	-	-	2.0	119	316
5-6	Cohesive	0.76	1	18.0	80.0	-	200	-	0.5	-	-	-	-	-	2.0	119	436
6-7	Cohesive	0.76	1	18.0	98.0	-	200	-	0.5	-	-	-	-	-	2.0	119	555
7-8	Cohesive	0.76	1	18.0	116.0	-	200	-	0.5	-	-	-	-	-	2.0	119	675
8-9	Rock	0.76	1	21.0	135.5	45	-	368	-	0.75	0.5	-	-	-	2.0	165	839
9-10	Rock	0.76	1	21.0	156.5	45	-	368	-	0.75	0.5	-	-	-	2.0	165	1004
10-11	Rock	0.76	1	21.0	177.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	299	1303
11-12	Rock	0.76	1	21.0	198.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	299	1601
12-13	Rock	0.76	1	21.0	219.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	299	1900
13-14	Rock	0.76	1	21.0	240.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	299	2199

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-23

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	FILL	1.00	1	0.0	0.0	0	-	-	-	-	-	0	0.00	1.000	2.0	0	0
1-2	Cohesionless	1.00	1	17.0	8.5	29	-	-	-	-	-	29	0.55	0.515	2.0	4	4
2-3	Cohesive	1.00	1	18.0	26.0	-	125	-	0.5	-	-	-	-	-	2.0	98	102
3-4	Cohesive	1.00	1	18.0	44.0	-	200	-	0.5	-	-	-	-	-	2.0	157	259
4-5	Cohesive	1.00	1	18.0	62.0	-	200	-	0.5	-	-	-	-	-	2.0	157	416
5-6	Cohesive	1.00	1	18.0	80.0	-	200	-	0.5	-	-	-	-	-	2.0	157	573
6-7	Cohesive	1.00	1	18.0	98.0	-	200	-	0.5	-	-	-	-	-	2.0	157	731
7-8	Cohesive	1.00	1	18.0	116.0	-	200	-	0.5	-	-	-	-	-	2.0	157	888
8-9	Rock	1.00	1	21.0	135.5	45	-	368	-	0.75	0.5	-	-	-	2.0	217	1105
9-10	Rock	1.00	1	21.0	156.5	45	-	368	-	0.75	0.5	-	-	-	2.0	217	1321
10-11	Rock	1.00	1	21.0	177.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	393	1714
11-12	Rock	1.00	1	21.0	198.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	393	2107
12-13	Rock	1.00	1	21.0	219.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	393	2500
13-14	Rock	1.00	1	21.0	240.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	393	2893

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-23

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	FILL	1.20	1	0.0	0.0	0	-	-	-	-	-	0	0.00	1.000	2.0	0	0
1-2	Cohesionless	1.20	1	17.0	8.5	29	-	-	-	-	-	29	0.55	0.515	2.0	5	5
2-3	Cohesive	1.20	1	18.0	26.0	-	125	-	0.5	-	-	-	-	-	2.0	118	122
3-4	Cohesive	1.20	1	18.0	44.0	-	200	-	0.5	-	-	-	-	-	2.0	189	311
4-5	Cohesive	1.20	1	18.0	62.0	-	200	-	0.5	-	-	-	-	-	2.0	189	500
5-6	Cohesive	1.20	1	18.0	80.0	-	200	-	0.5	-	-	-	-	-	2.0	189	688
6-7	Cohesive	1.20	1	18.0	98.0	-	200	-	0.5	-	-	-	-	-	2.0	189	877
7-8	Cohesive	1.20	1	18.0	116.0	-	200	-	0.5	-	-	-	-	-	2.0	189	1065
8-9	Rock	1.20	1	21.0	135.5	45	-	368	-	0.75	0.5	-	-	-	2.0	260	1326
9-10	Rock	1.20	1	21.0	156.5	45	-	368	-	0.75	0.5	-	-	-	2.0	260	1586
10-11	Rock	1.20	1	21.0	177.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	471	2057
11-12	Rock	1.20	1	21.0	198.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	471	2529
12-13	Rock	1.20	1	21.0	219.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	471	3000
13-14	Rock	1.20	1	21.0	240.5	45	-	1000	-	0.5	0.5	-	-	-	2.0	471	3471

ALLOWABLE END BEARING RESISTANCE :
BH-23

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Nϕ	q_{uc} (kN/m^2)	FOS	Q_{END} (kN)
Rock	760.0	11.0	4.5	1000.0	3.0	1361
Rock	760.0	14.0	4.5	1000.0	3.0	1361
Rock	760.0	11.0	4.5	1000.0	3.0	1361
Rock	760.0	14.0	4.5	1000.0	3.0	1361
Rock	1000.0	11.0	4.5	1000.0	3.0	2357
Rock	1000.0	14.0	4.5	1000.0	3.0	2357

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-26 & BH-27

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	0.76	1	16.5	8.25	26	-	-	-	-	-	26	0.49	0.561	2.0	3	3
2-3	cohesionless	0.76	1	8	20.50	31	-	-	-	-	-	31	0.60	0.485	2.0	7	10
3-4	cohesionless	0.76	1	8	28.50	31	-	-	-	-	-	31	0.60	0.485	2.0	10	20
4-5	cohesive	0.76	1	6.5	35.75	-	15	-	0.5	-	-	-	-	-	2.0	9	29
5-6	cohesionless	0.76	1	7.5	42.75	28	-	-	-	-	-	28	0.53	0.530	2.0	14	43
6-7	cohesive	0.76	1	6.5	49.75	-	15	-	0.5	-	-	-	-	-	2.0	9	52
7-8	cohesive	0.76	1	6.5	56.25	-	15	-	0.5	-	-	-	-	-	2.0	9	61
8-9	cohesive	0.76	1	6.5	62.75	-	15	-	0.5	-	-	-	-	-	2.0	9	70
9-10	cohesionless	0.76	1	8	70.00	31	-	-	-	-	-	31	0.60	0.485	2.0	24	94
10-11	cohesionless	0.76	1	8	78.00	31	-	-	-	-	-	31	0.60	0.485	2.0	27	121
11-12	cohesionless	0.76	1	9	86.50	36	-	-	-	-	-	36	0.73	0.412	2.0	31	152

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-26 & BH-27

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	1.00	1	16.5	8.25	26	-	-	-	-	-	26	0.49	0.561	2.0	4	4
2-3	cohesionless	1.00	1	8	20.50	31	-	-	-	-	-	31	0.60	0.485	2.0	9	13
3-4	cohesionless	1.00	1	8	28.50	31	-	-	-	-	-	31	0.60	0.485	2.0	13	26
4-5	cohesive	1.00	1	6.5	35.75	-	15	-	0.5	-	-	-	-	-	2.0	12	38
5-6	cohesionless	1.00	1	7.5	42.75	28	-	-	-	-	-	28	0.53	0.530	2.0	19	57
6-7	cohesive	1.00	1	6.5	49.75	-	15	-	0.5	-	-	-	-	-	2.0	12	68
7-8	cohesive	1.00	1	6.5	56.25	-	15	-	0.5	-	-	-	-	-	2.0	12	80
8-9	cohesive	1.00	1	6.5	62.75	-	15	-	0.5	-	-	-	-	-	2.0	12	92
9-10	cohesionless	1.00	1	8	70.00	31	-	-	-	-	-	31	0.60	0.485	2.0	32	124
10-11	cohesionless	1.00	1	8	78.00	31	-	-	-	-	-	31	0.60	0.485	2.0	36	160
11-12	cohesionless	1.00	1	9	86.50	36	-	-	-	-	-	36	0.73	0.412	2.0	41	200

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION :
BH-26 & BH-27

Depth	Strata Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Fill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-2	cohesionless	1.20	1	16.5	8.25	26	-	-	-	-	-	26	0.49	0.561	2.0	4	4
2-3	cohesionless	1.20	1	8	20.50	31	-	-	-	-	-	31	0.60	0.485	2.0	11	16
3-4	cohesionless	1.20	1	8	28.50	31	-	-	-	-	-	31	0.60	0.485	2.0	16	31
4-5	cohesive	1.20	1	6.5	35.75	-	15	-	0.5	-	-	-	-	-	2.0	14	45
5-6	cohesionless	1.20	1	7.5	42.75	28	-	-	-	-	-	28	0.53	0.530	2.0	23	68
6-7	cohesive	1.20	1	6.5	49.75	-	15	-	0.5	-	-	-	-	-	2.0	14	82
7-8	cohesive	1.20	1	6.5	56.25	-	15	-	0.5	-	-	-	-	-	2.0	14	96
8-9	cohesive	1.20	1	6.5	62.75	-	15	-	0.5	-	-	-	-	-	2.0	14	110
9-10	cohesionless	1.20	1	8	70.00	31	-	-	-	-	-	31	0.60	0.485	2.0	38	149
10-11	cohesionless	1.20	1	8	78.00	31	-	-	-	-	-	31	0.60	0.485	2.0	43	192
11-12	cohesionless	1.20	1	9	86.50	36	-	-	-	-	-	36	0.73	0.412	2.0	49	240

ALLOWABLE END BEARING RESISTANCE :
BH-26 & BH-27

Socket Strata	Diameter of Pile (mm)	Length of Pile (m)	Nc	Nq	Overburden pressure (kPa)	Cohesion (kPa)	FOS	Q_{END} (kN)	Qend + Qskin (kN)
Cohesionless	760.0	12.0	-	40.0	86.5	-	2.0	784	937
Cohesionless	1000.0	12.0	-	40.0	86.5	-	2.0	1358	1558
Cohesionless	1200.0	12.0	-	40.0	86.5	-	2.0	1956	2196

Appendix G

Liquefaction Potential Analysis

Liquefaction Assessment Report

PEYSANJ
geotechnical engineering software

Designed & Programmed by: Alireza Afkhami (MASc, MCP, PEng)
www.NovotechSoftware.com

PGA max : 0.2
M=6.6
Water Level : 0.01 m
Analysis Method : NCEER Workshop (1996)
MSF Method : Ambraseys (1988)
MSF = 1.6
Minimum Required Factor of Safety : 1

Depth (m)	SPT
1	4
2	26
3	17
4	5
5	3
6	36
7	2
8	11
9	11
10	32
11	50
12	50
13	50
14	50
15	50
16	50
17	50
18.5	50
20	50
21.5	50
23	50
24.5	50
26	50
27.5	50
29	50

Thickness (m)	Density (kN/m3)	Bottom (m)	D50 (mm)	Fines Content (%)
0.5	16.5	0.5	0.183	23.6
1.5	16.5	2	0.183	23.6
1.5	18	3.5	0.183	23.6
2	16.5	5.5	0.003	94.6
1	18.5	6.5	0.183	23.6
1	16	7.5	0.003	94.6
2.5	17.5	10	0.183	23.6
2.5	19	12.5	0.183	23.6
5	18.5	17.5	0.004	90.6
3	19	20.5	0.183	23.6
4	18.5	24.5	0.002	98.6
4.5	21	29	0.183	23.6

Project Title: BRTS, Yellow Line (BH-13)
Client: M/s. NESPAK
Address: Main Korangi Road, Karachi
Job Code: K19-1092-101

SOIL TESTING SERVICES

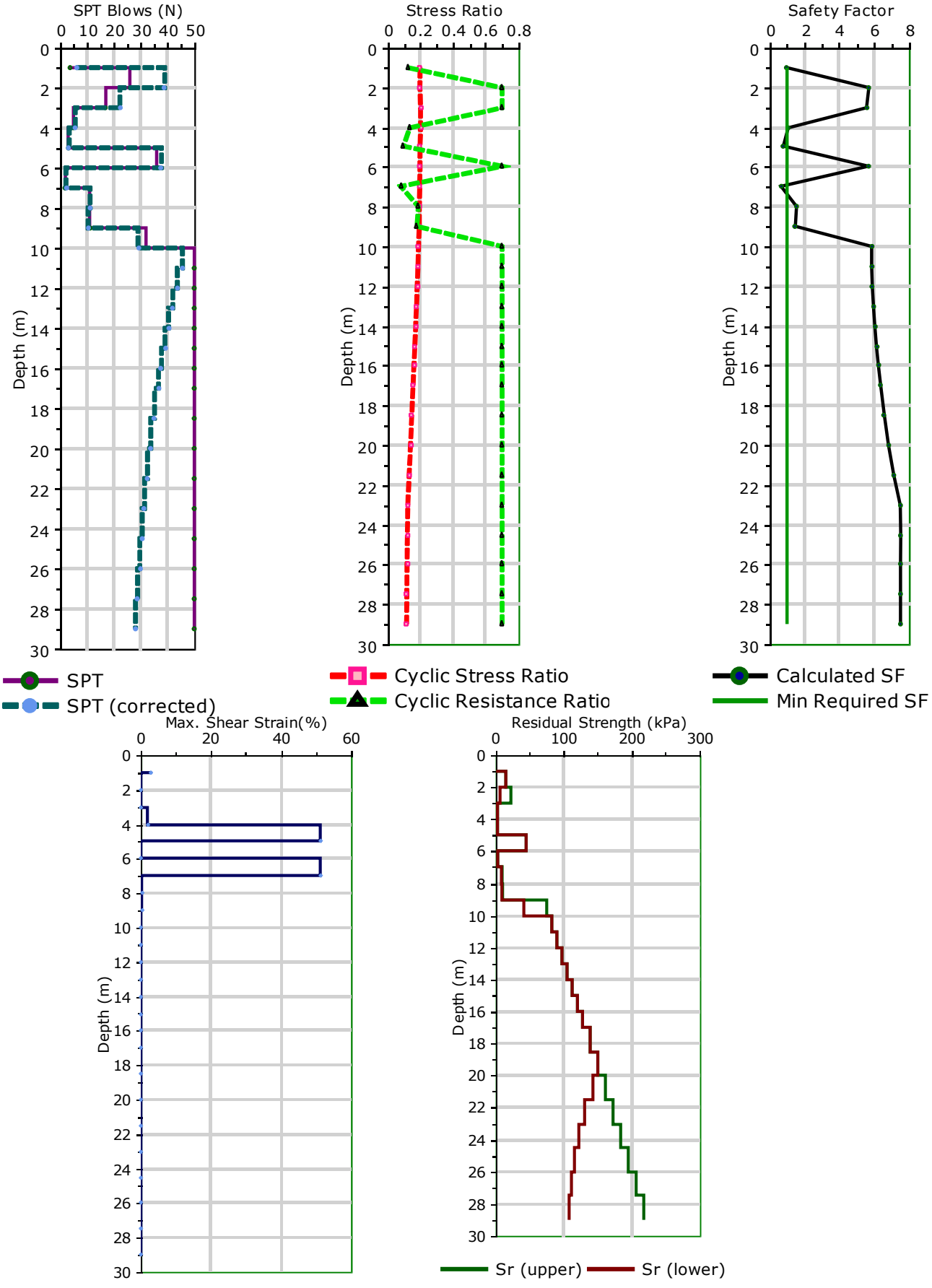
.:. Notes:
Sv : Total overburden stress S'v : Effective overburden stress
Cn : SPT correction factor Ks : K(sigma) due to the effect of overburden stress
CRR : Cyclic Resistance Ratio CSR : Cyclic Stress Ratio
LDI : Lateral Displacement Index St : Post-liquefaction settlement of the site
Sr : Post-liquefaction residual strength

.:. Total estimated post-liquefaction movements:
Lateral Displacement =0.86 m
Site Settlement =0 m

Depth (m)	Sv (kPa)	S'v (kPa)	D50 (mm)	SPT	Cn	Corr. SPT	Ks	CRR	CSR	Factor of Safety	Max. Shear Strain (%)	LDI (m)	St (m)	Min. Sr (kPa)	Max. Sr (kPa)
1	16.5	10.76	0.183	4	1.5	6	1	0.12	0.198	1.01	3.1	3.1	0	0.01	0.01
2	32.99	21.47	0.183	26	1.5	39	1	>0.7	0.197	5.69	0	3.1	0	0.15	0.15
3	50.99	32.17	0.183	17	1.31	22.3	1	>0.7	0.201	5.56	0	3.1	0	0.07	0.23
4	68.23	42.88	0.003	5	1.13	5.7	1	0.13	0.201	1.07	1.88	4.98	0	0.03	0.03
5	84.73	53.58	0.003	3	1.15	3.4	1	0.1	0.198	0.78	51.2	56.18	0	0.03	0.03
6	102.22	64.28	0.183	36	1.05	37.8	1	>0.7	0.197	5.67	0	56.18	0	0.46	0.46
7	119.47	74.99	0.003	2	1.09	2.2	1	0.08	0.196	0.65	51.2	107.38	0	0.03	0.03
8	136.21	85.69	0.183	11	1.02	11.2	1	0.19	0.194	1.54	0.22	107.6	0	0.09	0.1
9	153.71	96.4	0.183	11	0.96	10.5	1	0.18	0.193	1.48	0.25	107.85	0	0.09	0.1
10	171.2	107.1	0.183	32	0.91	29.1	0.99	>0.7	0.188	5.85	0	107.85	0	0.42	0.76
11	190.2	117.81	0.183	50	0.91	45.6	0.97	>0.7	0.185	5.86	0	107.85	0	0.84	0.84
12	209.19	128.51	0.183	50	0.87	43.7	0.95	>0.7	0.181	5.9	0	107.85	0	0.92	0.92
13	227.94	139.21	0.004	50	0.84	42	0.94	>0.7	0.176	5.96	0	107.85	0	0.99	0.99
14	246.43	149.92	0.004	50	0.81	40.4	0.92	>0.7	0.171	6.04	0	107.85	0	1.07	1.07
15	264.93	160.62	0.004	50	0.78	39.1	0.91	>0.7	0.166	6.13	0	107.85	0	1.15	1.15
16	283.42	171.33	0.004	50	0.76	37.8	0.9	>0.7	0.161	6.24	0	107.85	0	1.22	1.22
17	301.92	182.03	0.004	50	0.73	36.7	0.88	>0.7	0.155	6.37	0	107.85	0	1.3	1.3
18.5	330.16	198.09	0.183	50	0.7	35.2	0.87	>0.7	0.147	6.58	0	107.85	0	1.41	1.41
20	358.65	214.15	0.183	50	0.68	33.8	0.85	>0.7	0.139	6.82	0	107.85	0	1.53	1.53
21.5	386.64	230.2	0.002	50	0.65	32.6	0.83	>0.7	0.131	7.13	0	107.85	0	1.46	1.64
23	414.38	246.26	0.002	50	0.63	31.5	0.82	>0.7	0.122	7.5	0	107.85	0	1.33	1.76
24.5	442.13	262.32	0.002	50	0.61	30.6	0.81	>0.7	0.12	7.53	0	107.85	0	1.24	1.87
26	473.62	278.37	0.183	50	0.59	29.7	0.8	>0.7	0.119	7.51	0	107.85	0	1.18	1.99
27.5	505.11	294.43	0.183	50	0.58	28.9	0.78	>0.7	0.117	7.51	0	107.85	0	1.13	2.1
29	536.6	310.48	0.183	50	0.56	28.1	0.77	>0.7	0.115	7.52	0	107.85	0	1.1	2.22

Project Title: BRTS, Yellow Line (BH-13)
Client: M/s. NESPAK
Address: Main Korangi Road, Karachi
Job Code: K19-1092-101

SOIL TESTING SERVICES



Liquefaction Assessment Report

PEYSANJ
geotechnical engineering software

Designed & Programmed by: Alireza Afkhami (MASc, MCP, PEng)
www.NovotechSoftware.com

PGA max : 0.2
M=6.6
Water Level : 0.01 m
Analysis Method : NCEER Workshop (1996)
MSF Method : Ambraseys (1988)
MSF = 1.6
Minimum Required Factor of Safety : 1

Depth (m)	SPT
1	24
2	8
3	36
4	5
5	3
6	44
7	44
8	44
9	10
10	50
11	50
12	50
13	50
14	50
15	50
16	50
17.5	50
19	50
20.5	50
22	50
23.5	50
25	50
26.5	50
28	50
29.5	50

Thickness (m)	Density (kN/m3)	Bottom (m)	D50 (mm)	Fines Content (%)
0.5	16.5	0.5	0.204	5
3	18	3.5	0.204	5
1.5	16.5	5	0.008	73.4
3	19	8	0.195	29.2
2	17.5	10	0.008	73.4
2.5	18.5	12.5	0.008	73.4
3	19	15.5	1.377	10.1
9.5	18.5	25	0.008	73.4
5	21	30	1.377	10.1
		30		

Project Title: BRTS, Yellow Line (BH-15)
Client: M/s. NESPAK
Address: Main Korangi Road, Karachi
Job Code: K19-1092-101

SOIL TESTING SERVICES

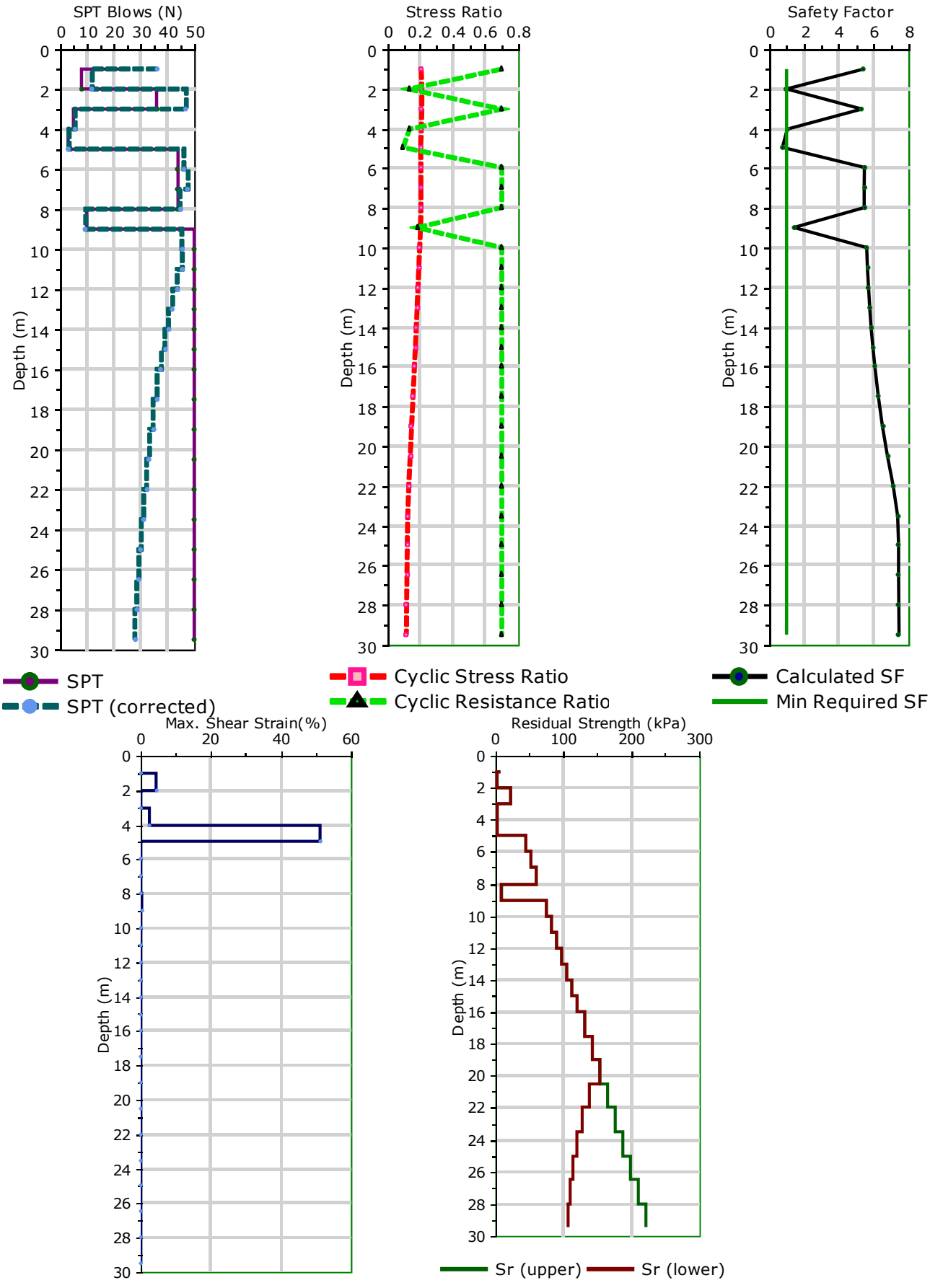
.:. Notes:
Sv : Total overburden stress S'v : Effective overburden stress
Cn : SPT correction factor Ks : K(sigma) due to the effect of overburden stress
CRR : Cyclic Resistance Ratio CSR : Cyclic Stress Ratio
LDI : Lateral Displacement Index St : Post-liquefaction settlement of the site
Sr : Post-liquefaction residual strength

.:. Total estimated post-liquefaction movements:
Lateral Displacement =0.47 m
Site Settlement =0.02 m

Depth (m)	Sv (kPa)	S'v (kPa)	D50 (mm)	SPT	Cn	Corr. SPT	Ks	CRR	CSR	Factor of Safety	Max. Shear Strain (%)	LDI (m)	St (m)	Min. Sr (kPa)	Max. Sr (kPa)
1	17.25	10.76	0.204	24	1.5	36	1	>0.7	0.207	5.41	0	0	0	0.08	0.08
2	35.24	21.47	0.204	8	1.5	12	1	0.13	0.21	1	4.36	4.36	0.02	0.02	0.03
3	53.24	32.17	0.204	36	1.31	47.1	1	>0.7	0.21	5.32	0	4.36	0.02	0.23	0.23
4	70.48	42.88	0.008	5	1.13	5.7	1	0.13	0.207	1.04	2.44	6.8	0.02	0.03	0.03
5	86.98	53.58	0.008	3	1.15	3.4	1	0.1	0.203	0.76	51.2	58	0.02	0.03	0.03
6	105.97	64.28	0.195	44	1.05	46.2	1	>0.7	0.204	5.47	0	58	0.02	0.46	0.46
7	124.97	74.99	0.195	44	1.09	47.8	1	>0.7	0.205	5.46	0	58	0.02	0.54	0.54
8	143.96	85.69	0.195	44	1.02	44.7	1	>0.7	0.205	5.46	0	58	0.02	0.61	0.61
9	161.46	96.4	0.008	10	0.96	9.6	1	0.18	0.203	1.42	0.28	58.28	0.02	0.09	0.09
10	178.95	107.1	0.008	50	0.91	45.4	0.99	>0.7	0.197	5.6	0	58.28	0.02	0.76	0.76
11	197.45	117.81	0.008	50	0.91	45.6	0.97	>0.7	0.192	5.65	0	58.28	0.02	0.84	0.84
12	215.94	128.51	0.008	50	0.87	43.7	0.95	>0.7	0.186	5.71	0	58.28	0.02	0.92	0.92
13	234.68	139.21	1.377	50	0.84	42	0.94	>0.7	0.181	5.78	0	58.28	0.02	0.99	0.99
14	253.68	149.92	1.377	50	0.81	40.4	0.92	>0.7	0.176	5.86	0	58.28	0.02	1.07	1.07
15	272.67	160.62	1.377	50	0.78	39.1	0.91	>0.7	0.171	5.96	0	58.28	0.02	1.15	1.15
16	291.42	171.33	0.008	50	0.76	37.8	0.9	>0.7	0.165	6.07	0	58.28	0.02	1.22	1.22
17.5	319.16	187.38	0.008	50	0.72	36.2	0.88	>0.7	0.156	6.27	0	58.28	0.02	1.34	1.34
19	346.9	203.44	0.008	50	0.69	34.7	0.86	>0.7	0.148	6.51	0	58.28	0.02	1.45	1.45
20.5	374.65	219.5	0.008	50	0.67	33.4	0.84	>0.7	0.139	6.8	0	58.28	0.02	1.57	1.57
22	402.39	235.55	0.008	50	0.65	32.3	0.83	>0.7	0.13	7.13	0	58.28	0.02	1.41	1.68
23.5	430.13	251.61	0.008	50	0.62	31.2	0.82	>0.7	0.124	7.39	0	58.28	0.02	1.3	1.8
25	457.87	267.67	0.008	50	0.61	30.3	0.8	>0.7	0.121	7.43	0	58.28	0.02	1.22	1.91
26.5	489.36	283.72	1.377	50	0.59	29.4	0.79	>0.7	0.119	7.43	0	58.28	0.02	1.16	2.03
28	520.86	299.78	1.377	50	0.57	28.6	0.78	>0.7	0.117	7.44	0	58.28	0.02	1.12	2.14
29.5	552.35	315.84	1.377	50	0.56	27.9	0.77	>0.7	0.115	7.46	0	58.28	0.02	1.09	2.26

Project Title: BRTS, Yellow Line (BH-15)
Client: M/s. NESPAK
Address: Main Korangi Road, Karachi
Job Code: K19-1092-101

SOIL TESTING SERVICES



Appendix H

Bearing Capacity Calculations

Bearing Capacity Analysis Report
(Isolated foundation (rectangular)

PEYSANJ
geotechnical engineering software

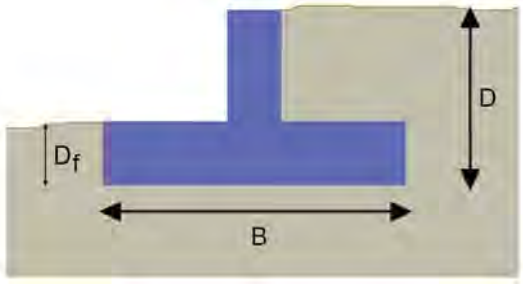
Designed & Programmed by: Alireza Afkhami (MASc, MCP, PEng)
www.NovotechSoftware.com

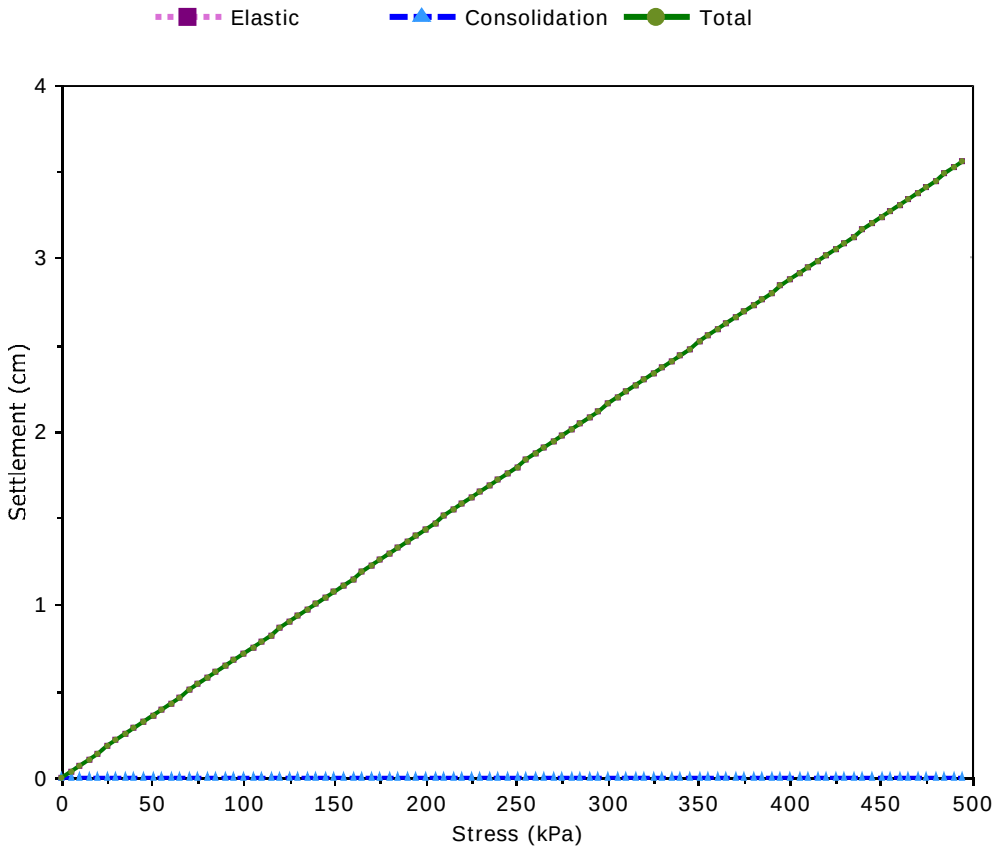
Soil Layer	Thickness (m)	Bottom (m)	Density (kN/m3)	C (kPa)	F (o)	Es (kPa)	Poisson Ratio	Void Ratio	Cc	Cs	Pc (kPa)	Pre -consolidated
SAND	1	1	17.5	0	29	13000	0.33	0.4	0	0	0	False
SAND	4	5	18	0	32	19500	0.32	0.36	0	0	0	False
SAND	3.5	8.5	19	0	36	50000	0.33	0.35	0	0	0	False
CLAY	3	11.5	19	200	0	50000	0.32	0.4	0.04	0.008	100	True
SAND	3	14.5	19	0	36	50000	0.32	0.35	0	0	0	False
SILT	3.5	18	19	200	0	20000	0.32	0.4	0.03	0.006	200	True

Parameter	Value	Units
Ave. Unit Weight of Soil Above the Footing	17	kN/m3
Groundwater Level (below footing)	5.0	m
Factor of Safety	3	-
Allowable Settlement	2.54	cm
Reloading Factor (Er/Es)	1	-
Rigidity Factor	1	-
Unsaturated Cons. Settl. Factor	1	-

Parameter	Value	Units
Width - B	2	m
Length - L	4	m
Df	2	m
Excavation Depth	2	m
Horizontal Load (B direction)	0	kN
Horizontal Load (L direction)	0	kN
Vertical Load	0	kN
Moment (around B)	0	kN.m
Moment (around L)	0	kN.m

$$q_{ult} = C.N_c.S_c.d_c.i_c.g_c.b_c + q.N_q.S_q.d_q.i_q.g_q.b_q + \frac{1}{2}\gamma.B'.N\gamma.S\gamma.d\gamma.i\gamma.g\gamma.b\gamma$$




Elastic
Consolidation
Total
Settlement (cm)
Stress (kPa)
0
1
2
3
4
0
50
100
150
200
250
300
350
400
450
500

.:.Notes:
Hs: shear wedge depth
Gamma: Soil unit weight
eB, eL : Load eccentrity
Af : Effective area of the footing=B'.L'
q' : Overburden stress at the level of foundation=gamma.Df

B (m)	L (m)	Ave. Es (kPa)	Ave. v	Hs (m)	i1	i2	Is	Fox If	Stress (kPa)	Se (cm)	Consolidation Notes	Sc (cm)	Se+Sc (cm)
		0											
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	5	0.04	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.04
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	10	0.07	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.07
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	15	0.11	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.11
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	20	0.14	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.14
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	25	0.18	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.18
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	30	0.22	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.22
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	35	0.25	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.25

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	40	0.29	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.29
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	45	0.32	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.32
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	50	0.36	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.36
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	55	0.4	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.4
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	60	0.43	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.43
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	65	0.47	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.47
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	70	0.5	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.5
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	75	0.54	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.54
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	80	0.58	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.58

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	85	0.61	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.61
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	90	0.65	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.65
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	95	0.68	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.68
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	100	0.72	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.72
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	105	0.75	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.75
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	110	0.79	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.79
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	115	0.83	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.83
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	120	0.86	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.86
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	125	0.9	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.9

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	130	0.93	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.93
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	135	0.97	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	0.97
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	140	1.01	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.01
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	145	1.04	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.04
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	150	1.08	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.08
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	155	1.11	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.11
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	160	1.15	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.15
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	165	1.19	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.19
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	170	1.22	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.22

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	175	1.26	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.26
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	180	1.29	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.29
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	185	1.33	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.33
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	190	1.37	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.37
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	195	1.4	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.4
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	200	1.44	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.44
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	205	1.47	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.47
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	210	1.51	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.51
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	215	1.55	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.55

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	220	1.58	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.58
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	225	1.62	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.62
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	230	1.65	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.65
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	235	1.69	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.69
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	240	1.73	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.73
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	245	1.76	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.76
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	250	1.8	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.8
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	255	1.83	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.83
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	260	1.87	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.87

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	265	1.9	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.9
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	270	1.94	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.94
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	275	1.98	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	1.98
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	280	2.01	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.01
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	285	2.05	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.05
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	290	2.08	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.08
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	295	2.12	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.12
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	300	2.16	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.16
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	305	2.19	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.19

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	310	2.23	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.23
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	315	2.26	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.26
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	320	2.3	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.3
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	325	2.34	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.34
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	330	2.37	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.37
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	335	2.41	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.41
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	340	2.44	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.44
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	345	2.48	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.48
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	350	2.52	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.52

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	355	2.55	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.55
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	360	2.59	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.59
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	365	2.62	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.62
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	370	2.66	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.66
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	375	2.7	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.7
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	380	2.73	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.73
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	385	2.77	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.77
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	390	2.8	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.8
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	395	2.84	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.84

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	400	2.88	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.88
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	405	2.91	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.91
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	410	2.95	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.95
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	415	2.98	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	2.98
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	420	3.02	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.02
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	425	3.05	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.05
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	430	3.09	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.09
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	435	3.13	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.13
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	440	3.16	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.16

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	445	3.2	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.2
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	450	3.23	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.23
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	455	3.27	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.27
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	460	3.31	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.31
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	465	3.34	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.34
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	470	3.38	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.38
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	475	3.41	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.41
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	480	3.45	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.45
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	485	3.49	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.49

2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	490	3.52	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.52
2	4	17841.84	0.32	3.92	0.471	0.07	0.508	0.705	495	3.56	H=3.92 m .:. Layer #4(CLAY) N/A .:. Layer #6(SILT) N/A	0	3.56

Bearing Capacity Analysis Report (Strip / Pad footing)

PEYSANJ
geotechnical engineering software

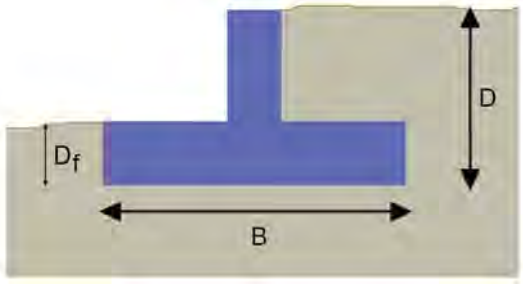
Designed & Programmed by: Alireza Afkhami (MASc, MCP, PEng)
www.NovotechSoftware.com

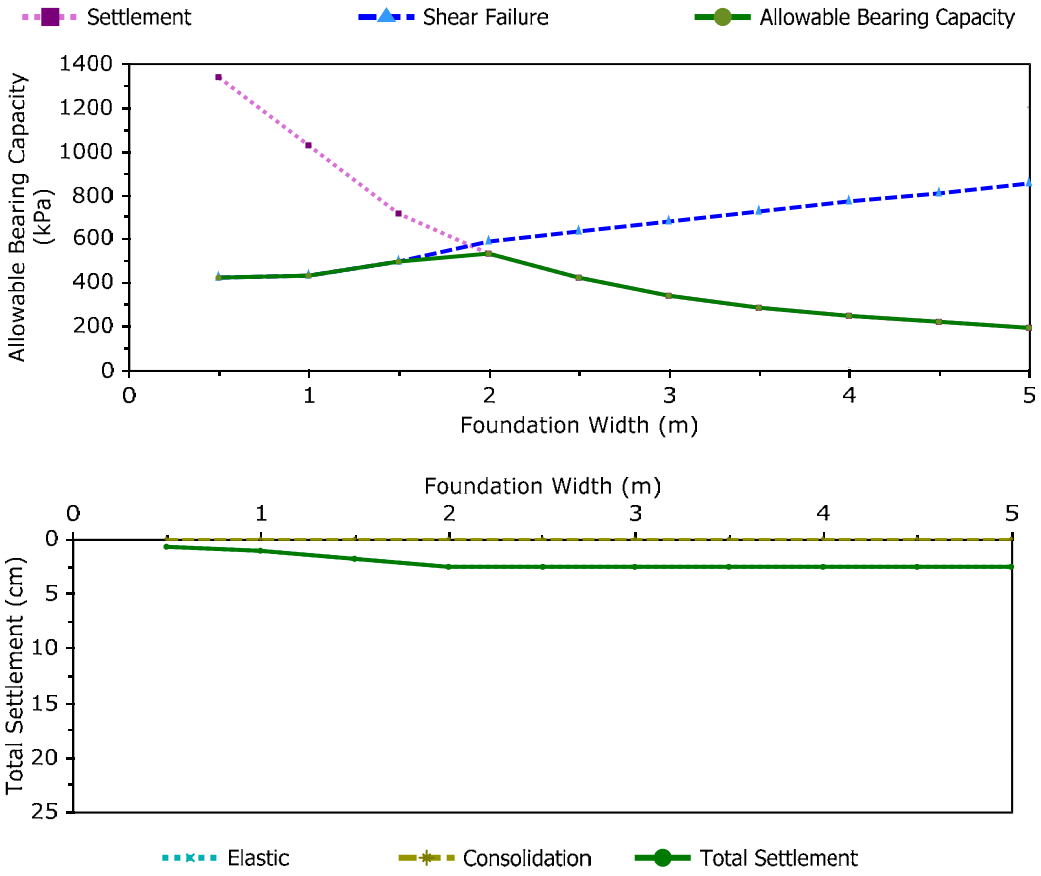
Soil Layer	Thickness (m)	Bottom (m)	Density (kN/m3)	C (kPa)	F (o)	Es (kPa)	Poisson Ratio	Void Ratio	Cc	Cs	Pc (kPa)	Pre -consolidated
SAND	1	1	17.5	0	31	13000	0.33	0.4	0	0	0	False
SAND	10	11	19	0	35	31500	0.32	0.35	0	0	0	False
SANDSTONE	1	12	21	50	40	100000	0.29	0.3	0	0	0	False
CLAY/SILT	3.5	15.5	18.5	200	0	50000	0.33	0.4	0.04	0.008	150	True
SAND	12.5	28	19	0	38	50000	0.32	0.35	0	0	0	False

Parameter	Value	Units
Ave. Unit Weight of Soil Above the Footing	17	kN/m3
Groundwater Level (below footing)	9	m
Factor of Safety	3	-
Allowable Settlement	2.54	cm
Reloading Factor (Er/Es)	1	-
Rigidity Factor	1	-
Unsaturated Cons. Settl. Factor	1	-

Parameter	Value	Units
L / B	2	-
Df	2	m
Excavation Depth	2	m
Horizontal Load (B direction)	0	kN
Horizontal Load (L direction)	0	kN
Vertical Load	0	kN
Moment (around B)	0	kN.m
Moment (around L)	0	kN.m

$$q_{ult} = C.N_c.S_c.d_c.i_c.g_c.b_c + q.N_q.S_q.d_q.i_q.g_q.b_q + \frac{1}{2}\gamma.B'.N\gamma.S\gamma.d\gamma.i\gamma.g\gamma.b\gamma$$




Settlement
Shear Failure
Allowable Bearing Capacity
Allowable Bearing Capacity (kPa)
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
Foundation Width (m)

Foundation Width (m)
0
1
2
3
4
5
Total Settlement (cm)
0
5
10
15
20
25
Elastic
Consolidation
Total Settlement

Project Title: GI FOR YELLOW BRTS LINE (BH-04)
Client: NESPAK (PVT.) LTD.
Address: KORANGI, KARACHI
Job Code: K19-1092-101

SOIL TESTING SERVICES

.:.Notes:
Hs: shear wedge depth
Gamma: Soil unit weight
eB, eL : Load eccentrity
Af : Effective area of the footing=B'.L'
q' : Overburden stress at the level of foundation=gamma.Df

B (m)	L (m)	Hs (m)	C_ave (kPa)	Phi_ave (deg)	Gamma_ave (kN/m3)	eB	eL	B'	L'	Af (m2)	Nc	Nq	Ng	Sc	Sq	Sg	Df/B	K	dc	dq	dg	Ca~0.8C (kPa)	q' (kPa)	Qu shear (kPa)
0.5	1	0.44	0	31	17.5	0	0	0.5	1	0.5	32.67	20.63	17.69	1.32	1.26	0.8	4	1.33	1.53	1.37	1	0	33.99	1274.18
1	2	0.88	0	31	17.5	0	0	1	2	2	32.67	20.63	17.69	1.32	1.26	0.8	2	1.11	1.44	1.31	1	0	33.99	1281.59
1.5	3	1.35	0	32.1	17.89	0	0	1.5	3	4.5	35.73	23.4	21.06	1.33	1.27	0.8	1.33	0.93	1.37	1.26	1	0	33.99	1489.74
2	4	1.83	0	32.9	18.18	0	0	2	4	8	38.19	25.67	23.91	1.34	1.27	0.8	1	1	1.4	1.27	1	0	33.99	1756.87
2.5	5	2.31	0	33.3	18.35	0	0	2.5	5	12.5	39.71	27.1	25.73	1.34	1.27	0.8	0.8	0.8	1.32	1.21	1	0	33.99	1897.12
3	6	2.79	0	33.6	18.46	0	0	3	6	18	40.74	28.08	27	1.34	1.28	0.8	0.67	0.67	1.27	1.18	1	0	33.99	2031.84
3.5	7	3.27	0	33.8	18.54	0	0	3.5	7	24.5	41.49	28.79	27.93	1.35	1.28	0.8	0.57	0.57	1.23	1.15	1	0	33.99	2164.01
4	8	3.76	0	34	18.6	0	0	4	8	32	42.05	29.33	28.63	1.35	1.28	0.8	0.5	0.5	1.2	1.13	1	0	33.99	2294.86
4.5	9	4.24	0	34.1	18.65	0	0	4.5	9	40.5	42.49	29.76	29.19	1.35	1.28	0.8	0.44	0.44	1.18	1.12	1	0	33.99	2424.98
5	10	4.72	0	34.2	18.68	0	0	5	10	50	42.85	30.1	29.65	1.35	1.28	0.8	0.4	0.4	1.16	1.1	1	0	33.99	2554.66

Bearing Capacity Analysis Report
(Isolated foundation (rectangular)

PEYSANJ
geotechnical engineering software

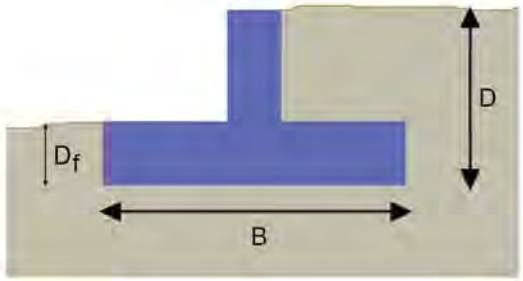
Designed & Programmed by: Alireza Afkhami (MASc, MCP, PEng)
www.NovotechSoftware.com

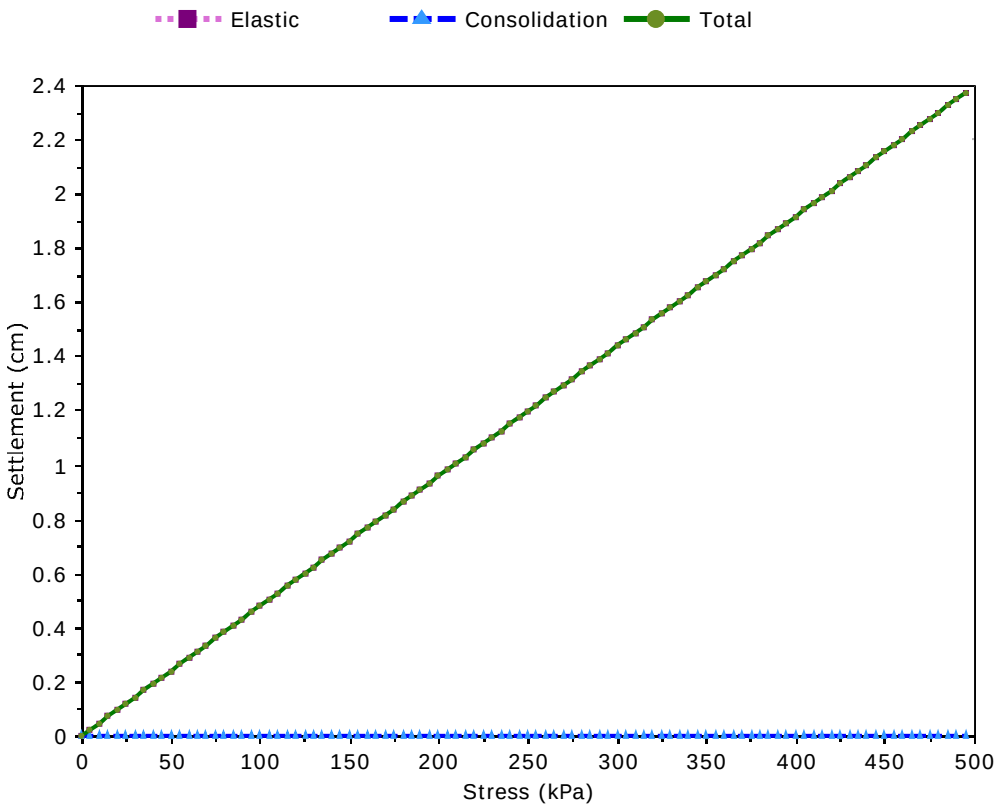
Soil Layer	Thickness (m)	Bottom (m)	Density (kN/m3)	C (kPa)	F (o)	Es (kPa)	Poisson Ratio	Void Ratio	Cc	Cs	Pc (kPa)	Pre -consolidated
SAND	1	1	17.5	0	31	13000	0.33	0.4	0	0	0	False
SAND	10	11	19	0	35	31500	0.32	0.35	0	0	0	False
SANDSTONE	1	12	21	50	40	100000	0.29	0.3	0	0	0	False
CLAY/SILT	3.5	15.5	18.5	200	0	50000	0.33	0.4	0.04	0.008	150	True
SAND	12.5	28	19	0	38	50000	0.32	0.35	0	0	0	False

Parameter	Value	Units
Ave. Unit Weight of Soil Above the Footing	17	kN/m3
Groundwater Level (below footing)	9	m
Factor of Safety	3	-
Allowable Settlement	2.54	cm
Reloading Factor (Er/Es)	1	-
Rigidity Factor	1	-
Unsaturated Cons. Settl. Factor	1	-

Parameter	Value	Units
Width - B	2	m
Length - L	4	m
Df	2	m
Excavation Depth	2	m
Horizontal Load (B direction)	0	kN
Horizontal Load (L direction)	0	kN
Vertical Load	0	kN
Moment (around B)	0	kN.m
Moment (around L)	0	kN.m

$$q_{ult} = C.N_c.S_c.d_c.i_c.g_c.b_c + q.N_q.S_q.d_q.i_q.g_q.b_q + \frac{1}{2}\gamma.B'.N_\gamma.S_\gamma.d_\gamma.i_\gamma.g_\gamma.b_\gamma$$




Elastic
Consolidation
Total
Settlement (cm)
Stress (kPa)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
0
50
100
150
200
250
300
350
400
450
500

.:.Notes:
Hs: shear wedge depth
Gamma: Soil unit weight
eB, eL : Load eccentrity
Af : Effective area of the footing=B'.L'
q' : Overburden stress at the level of foundation=gamma.Df

B (m)	L (m)	Ave. Es (kPa)	Ave. v	Hs (m)	i1	i2	Is	Fox If	Stress (kPa)	Se (cm)	Consolidation Notes	Sc (cm)	Se+Sc (cm)
		0											
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	5	0.02	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.02
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	10	0.05	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.05
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	15	0.07	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.07
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	20	0.1	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.1
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	25	0.12	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.12
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	30	0.14	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.14
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	35	0.17	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.17
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	40	0.19	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.19
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	45	0.22	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.22
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	50	0.24	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.24
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	55	0.26	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.26
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	60	0.29	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.29

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	65	0.31	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.31
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	70	0.34	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.34
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	75	0.36	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.36
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	80	0.38	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.38
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	85	0.41	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.41
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	90	0.43	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.43
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	95	0.45	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.45
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	100	0.48	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.48
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	105	0.5	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.5
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	110	0.53	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.53
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	115	0.55	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.55
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	120	0.57	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.57
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	125	0.6	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.6
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	130	0.62	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.62
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	135	0.65	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.65
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	140	0.67	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.67

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	145	0.69	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.69
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	150	0.72	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.72
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	155	0.74	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.74
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	160	0.77	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.77
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	165	0.79	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.79
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	170	0.81	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.81
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	175	0.84	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.84
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	180	0.86	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.86
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	185	0.89	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.89
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	190	0.91	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.91
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	195	0.93	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.93
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	200	0.96	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.96
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	205	0.98	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	0.98
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	210	1.01	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.01
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	215	1.03	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.03
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	220	1.05	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.05

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	225	1.08	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.08
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	230	1.1	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.1
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	235	1.13	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.13
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	240	1.15	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.15
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	245	1.17	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.17
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	250	1.2	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.2
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	255	1.22	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.22
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	260	1.25	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.25
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	265	1.27	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.27
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	270	1.29	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.29
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	275	1.32	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.32
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	280	1.34	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.34
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	285	1.36	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.36
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	290	1.39	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.39
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	295	1.41	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.41
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	300	1.44	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.44

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	305	1.46	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.46
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	310	1.48	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.48
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	315	1.51	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.51
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	320	1.53	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.53
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	325	1.56	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.56
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	330	1.58	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.58
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	335	1.6	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.6
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	340	1.63	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.63
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	345	1.65	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.65
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	350	1.68	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.68
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	355	1.7	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.7
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	360	1.72	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.72
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	365	1.75	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.75
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	370	1.77	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.77
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	375	1.8	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.8
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	380	1.82	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.82

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	385	1.84	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.84
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	390	1.87	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.87
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	395	1.89	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.89
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	400	1.92	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.92
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	405	1.94	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.94
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	410	1.96	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.96
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	415	1.99	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	1.99
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	420	2.01	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.01
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2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	430	2.06	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.06
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	435	2.08	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.08
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	440	2.11	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.11
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	445	2.13	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.13
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	450	2.15	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.15
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	455	2.18	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.18
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	460	2.2	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.2

2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	465	2.23	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.23
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	470	2.25	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.25
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	475	2.27	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.27
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	480	2.3	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.3
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	485	2.32	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.32
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	490	2.35	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.35
2	4	26780.61	0.32	3.92	0.471	0.07	0.508	0.705	495	2.37	H=3.92 m .:. Layer #4(CLAY/SILT) N/A	0	2.37

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Volume 5B - Hydrology and Hydraulics Study Report

Request For Proposal Documents Works (Design and Build)

Main Contents

VOLUME (1): **Instructions to Proposers (ITP) & Proposal Data Sheet (PDS), Proposal Forms / Schedules, Conditions of Contract, Contract Forms / Schedules**

Part 1 - Request for Proposal Procedures
Section I Instructions to Proposers (ITP)
Section II Proposal Data Sheet (PDS)
Section III Evaluation and Qualification Criteria
Section IV Proposal Forms
Section V Eligible Countries
Section VI Fraud and Corruption

Part 2 - Employer's Requirements
Section VII Employer's Requirements

Part 3 - Conditions of Contract and Contract Forms
Section VIII General Conditions (GC)
Section IX Particular Conditions (PC)
Section X Contract Forms

VOLUME (2):

Part (A) Employer's Requirements
1) Introduction
2) General Overview of the Project
3) Design Intent
4) Design Responsibility
5) Interface Management
6) Design Stages and Deliverables
7) Basis of Design

Part (B) Specifications (1 of 2)
Division 01 - General Requirements

Part (B) Specifications (2 of 2)
Division 02 - Site Construction
Division 03 - Concrete
Division 07 - Thermal and Moisture Protection
Division 26 - Electrical
Division 31 - Earthwork
Division 32 - Exterior Improvements
Division 33 - Utilities
Division 34 - Transportation

VOLUME (3): Basis of Pricing & Pricing Schedules

Basis of Pricing

Pricing Preambles
1 Design & Special Works
2 Bridge Works
3 Roadworks
4 Electrical Works
5 Utilities

Pricing Schedules

Summary
1 General and Particular Conditions of Contract
2 General Requirements
3 Design & Special Works
4 Bridge Works
5 Roadworks
6 Electrical Works
7 Utilities

VOLUME (4): Drawings

01- Roads
02- Bridge
04- Utilities

VOLUME (5): Technical Documents "For Information":

5A - Geotechnical Investigation
5B - Hydrology and Hydraulics Study Report
5C - Environmental and Social Management Plan
5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

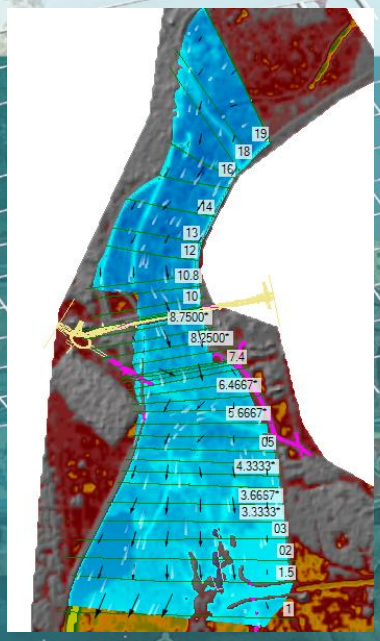
KARACHI MOBILITY PROJECT

Yellow Line BRT Corridor

HYDROLOGY AND HYDRAULICS STUDY REPORT – FOR PROPOSED FOUR LANES BRIDGE ADJACENT TO THE JAM SADIO BRIDGE.

P21161-4309

October 2022



CONTENTS

CONTENTS II
LIST OF TABLES IV
LIST OF FIGURES V
ANNEXURES VI
ABBREVIATIONS VII
1. INTRODUCTION 1
1.1 GENERAL 1
1.2 BACKGROUND 1
1.3 OBJECTIVE OF THE STUDY 4
1.4 PROJECT COMPONENTS 4
2. DATA COLLECTION AND INFORMATION 7
2.1 DATA COLLECTION 7
2.2 ADDITIONAL DATA 7
2.3 MEETING, FIELD VISITS OF STUDY AREA AND PHOTOGRAPHS 8
3. TOPOGRAPHIC SURVEY OF THE STUDY AREA 9
3.1 LOCATION & EXTENTS OF THE PROJECT SITE 9
3.2 SCOPE OF SURVEY WORK 10
4. HYDROLOGICAL STUDIES 12
4.1 OBJECTIVE OF HYDROLOGICAL STUDY REPORT 12
4.2 MALIR RIVER 12
4.3 REVIEW OF PREVIOUS STUDIES 13
4.3.1 Feasibility Report of Karachi Flood Control Plan - 1990 13
4.3.2 Survey, Feasibility and Detail Design for Re-Alignment of Bund from North Side of Malir River (NESPAK 2013) 13
4.4 DATA COLLECTION 14
4.5 DATA ANALYSIS 17

4.5.1 Design Hyetograph 17

4.5.2 Estimation of peak discharges 20

4.6 CONCLUSION AND RECOMMENDATIONS 26

5. DETAILED ENGINEERING DESIGN 28

5.1 MATHEMATICAL MODEL 28

5.2 INPUTS FOR MATHEMATICAL MODEL 28

5.3.1 Design Discharge 28

5.3.2 River Reach 29

5.3.3 River Cross Sections 31

5.3.4 Manning's Roughness Co-Efficient 31

5.3.5 Boundary Condition 31

5.3.6 Freeboard 34

5.3 RESULTS OF NUMERICAL MODEL STUDY 34

5.3.1 Scenario 1: Existing / Base Conditions 34

5.3.2 Scenario 2: Proposed Yellow Line Bridge Without any Proposed Interventions Works 34

5.3.3 Scenario 3: Proposed Yellow Line Bridge with All Proposed Project Works (Korangi Bridge Project Features) 35

Elev. = Elevation, Min. = Minimum Ch. = Channel 38

5.4 hydraulic geometry of Ybrt BRIDGE 41

5.4.1 Hydraulic Design Parameters 42

5.4.2 Freeboard 42

LIST OF TABLES

Table 1-1: Project Components 6
Table 4-1: Depth-Area-Duration Relationship for Mol & Khadeji Rivers (mm) 13
Table 4-2: Maximum Rainfall of Extra-ordinary Storms in the Sindh Province 15
Table 4-3: 25-27 August, 2020 Rainfall Event at Stations in Karachi 16
Table 4-4: 3-Hourly Observed Rainfall Depths (25-27 Aug 2020) at Karachi Airport 16
Table 4-5: One-Day Rainfall Depths of Various Return Period at Karachi Masroor 17
Table 4-6: Selection of Curve Numbers for the Sub-basins 20
Table 4-7: Time of Concentration of the Twenty-Eight Sub-Basins 24
Table 5-1: Manning's Roughness Coefficient Used in Model 31
Table 5-2: Simulation Results of Water Surface Profiles of Three (3) Scenarios 36
Table 5-3: Pier Parameters 40
Table 5-4: Hydraulic Parameters of Proposed YBRT Bridge 42

LIST OF FIGURES

Figure 1-1: Karachi BRT Lines 2
Figure 1-2: Location Map of Project Area 3
Figure 1-3: Yellow BRT Corridor and Project Components as per approved PC-1 5
Figure 4-1: Annual Instantaneous Peak Discharges at Supper Highway Bridge 14
Figure 4-2: One-Day Annual Maximum Rainfall (Karachi Masroor) 15
Figure 4-3: Plotting Positions and Fitted Line to One-Day Annual Maximum Rainfall Depths 17
Figure 4-4: 24-hr Maximized Time Distribution of August 2020 Event 18
Figure 4-5: Point to Area Reduction Curve for the Rainfall Event (Halcrow 1986) 19
Figure 4-6: 100-year Design Hyetograph for The Malir Basin at Bridge Site 19
Figure 4-7: 100-year Design Hyetograph For The Malir Basin at Bridge Site 23
Figure 4-8: Schematic Layout of Malir River in HEC-HMS Model 26
Figure 5-1: Layout of Existing Structures and Proposed Corridor 29
Figure 5-2: Malir River Study Reach 30
Figure 5-3: Layout Plan Showing Cross Section Lines 32
Figure 5-4: Cross Sections of the Study Reach 33
Figure 5-5: Water Surface Profile for Existing/ Base Condition 34
Figure 5-6: Water Surface Profile with Proposed Yellow Line Bridge 35
Figure 5-7: Water Surface Profile with Both Proposed Yellow Line Bridge (U/S) and Korangi Bridge Project (D/S) Features 36
Figure 5-8: Showing Scour Computation by HEC-RAS Model 41

ANNEXURES

Annexure A: Topographic Survey of the Study Area
Annexure B: Hydraulic Model Cross Sections of the Project Area

Abbreviations

BRT	Bus Rapid Transit
BM	Bench Marks
CN	Curve Number
CPs	Control Points
DEM	Digital Elevation Model
D/S	Down Stream
EBM	English Biscuit Manufacturers Causeway
GoS	Government of Sindh
GDOP	Geometric Dilution of Precision
HEC-RAS	Hydrological Engineering Centre – River Analysis System
HEPO	Hydro Electric Planning Organization
JICA	Japan International Cooperation Agency
JSB	Jam Sadiq Bridge
KPT	Karachi Port Trust
KNIP	Karachi Neighbourhood Improvement Program
KRB	Korangi Road Bridge
LGO	Leica Geo Office
NESPAK	National Engineering Services Pakistan
NIP	National Industrial Park
PBS	Pakistan Bureau of Statistics
PMD	Pakistan Meteorological Department
PARCO	Pak-Arab Refinery Company Limited
PMFs	Probable Maximum Floods
PMP	Probable Maximum Precipitation
PDOP	Position Dilution of Precision
RTK	Real Time Kinematic
SMTA	Sindh Mass Transit Authority

SOP	Survey of Pakistan
SRTM	Shuttle Radar Topographic Mission
SWHP	Surface Water Hydrology Project
TMTD	Transport & Mass Transit Department
TBC	Trimble Business Centre
u/s	Up Stream
UTM	Universal Transverse Mercator
USNRCS	United States Natural Resources Conservation Method
URI	Urban Road Initiatives
USACE	US Army Corps of Engineers
WAPDA	Water & Power Development Authority

1. INTRODUCTION

1.1 GENERAL

Karachi is the largest city in Pakistan, capital of the Province of Sindh and with an estimated population over 15 million (Pakistan Bureau of Statistics 2017). The area is expanding rapidly and population is expected to reach 18.08 million & 20.43 million by the years 2025 & 2030. Karachi is the major sea port of the country and the area provides the large parentage of the nation industrial production. Due to this phenomenal population growth, increase in vehicular traffic, congestion and traffic jam issues arise on major roads of city. Consequently, road users are facing inconvenience/hazards like wastage of time/fuel, environmental pollution (noise, smoke etc.) and accidents etc.

For providing better transport facilities to the residents of the Karachi, Sindh Government has been making utmost efforts. In line with the aforesaid, Sindh Government, through Sindh Mass Transit Authority (SMTA) and the Transport & Mass Transit Department (TMTD), is implementing the Karachi Mobility Project i.e., the Yellow Line Bus Rapid Transit (BRT) Corridor. The project is planned to be implemented through financial support of the World Bank. The corridor is about 21 km long starting from Dawood Chowrangi to Numaish Chowrangi. The proposed corridor will cross the Malir River by constructing a new bridge on Malir River. This arrangement will provide direct additional route to connect Karachi Port Trust (KPT) Interchange to Numaish Chowrangi (Yellow BRT).

1.2 BACKGROUND

The BRT Yellow Line is one of the priority Mass Transit Corridors proposed by JICA to overcome the traffic congestion problems in Karachi. According to the JICA study, future growth projections of cars and motorcycles indicated that traffic volumes would soon outpace available road space, and the current transport system will be subject to increased congestion and longer travel times, as well as worsening air quality.

The Preliminary Design for the Yellow BRT Corridor, which was initiated by Sindh Mass Transit Authority (SMTA) and funded by World Bank through the Karachi Neighbourhood Improvement Program (KNIP), was prepared by NESPAK and completed in 2019.

In September 2021, the Joint Venture of DAR and NESPAK (the JV) were assigned by SMTA to carry out consultancy and construction supervision services towards the successful implementation of the Yellow BRT Corridor, including detailed design, support during tender and construction supervision. The Notice to Commence for the Detailed Design Services was given on 24 September 2021.

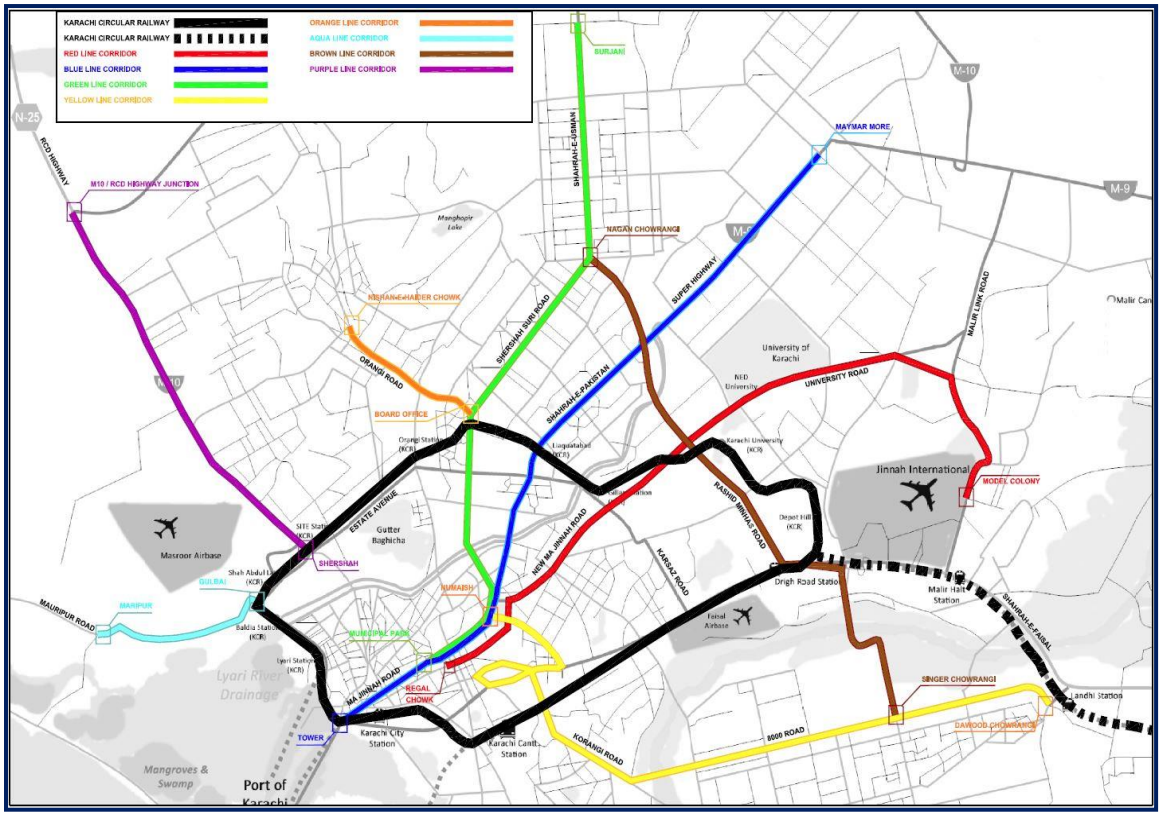


Figure 1-1: Karachi BRT Lines

Jam Sadiq Bridge (JSB) is the only bridge, connecting both banks of the Malir River in the vicinity of Korangi Industrial Area. Presently there are two causeways (i) English Biscuit Manufacturers (EBM) Causeway - U/S and (ii) Korangi Causeway - D/S of the JSB serving the traffic under normal flow conditions in the river. However, during the flood season both causeways get submerged due to high flood in Malir River and the JSB observes heavy traffic jams.

Government of Sindh (GoS) intends to construct two (2) new bridges on Malir River to reduce the traffic load on the existing JSB. One bridge is approximately 600 m downstream of the existing bridge (Korangi Road Bridge) and second one (Yellow BRT Bridge) adjacent (a few meters upstream side) of the existing JSB. For both the newly proposed bridges (one upstream (YL BRT) and second downstream (KRB), adopted reduced waterway/ length of bridge is almost similar to the existing JSB. The proposed bridges will run parallel to the existing JSB as they traverse the shortest route to connect both banks of the river. Existing left bund downstream of JSB will be extended up to the newly proposed downstream side KR Bridge to be constructed under another project of GoS (Sub-Project 1, Link Road to Korangi, Urban Road Initiatives). Location Map of the project area is shown in **Figure 1.2**.

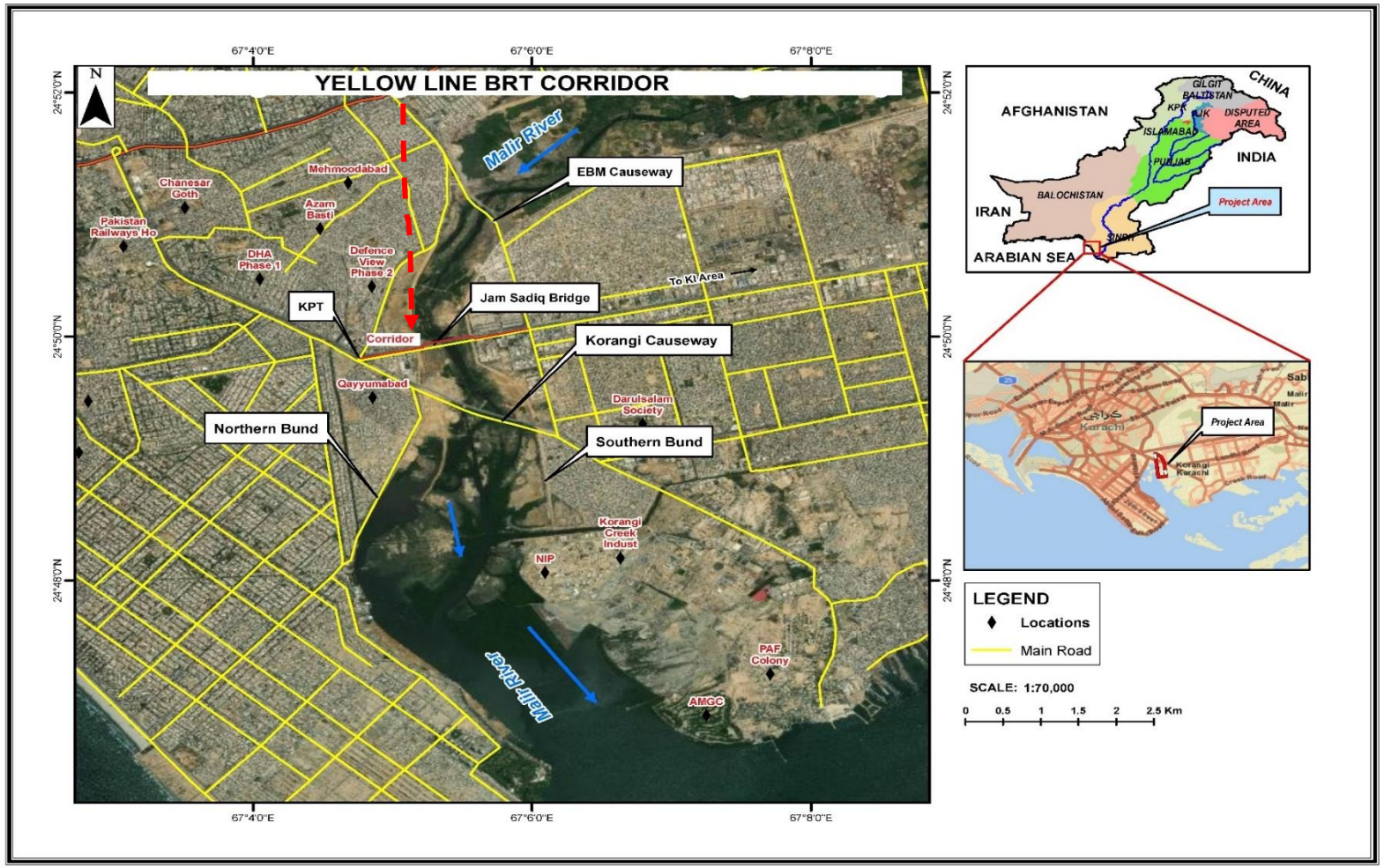


Figure 1-2: Location Map of Project Area

1.3 OBJECTIVE OF THE STUDY

The proposed project is high significance and its main objectives are:

i. To improve the flow of public transport in Karachi;
ii. Proposed bridge will be the part of route to be used by high quality and fast bus service (BRT);
iii. Determine/and estimate backwater effect and increase in water levels with respect to existing bunds up to English Biscuit Manufacturers Causeway; and
iv. Determine the hydraulic parameters of Malir River at proposed bridge upstream of JSB.

1.4 PROJECT COMPONENTS

The Yellow BRT Corridor is approximately 21 km long with a generally dedicated right-of-way, except for a circa 2 km section of mixed traffic (mostly along Shahrah-e-Faisal). The Project comprises a total of 28 stations as per preliminary designs and approved PC-1 of various sizes consistent with the expected demand.

The Yellow BRT Corridor connects several industrial, commercial and residential areas along the line, such as Korangi industrial area, Landhi Industrial area and Bin Qasim area. The proposed route also traverses residential and commercial zones such as Clifton Cantonment, Jamshed town, Karachi Cantonment and Saddar town.

Error! Reference source not found. below shows the extent of the Yellow BRT Corridor, while Error! Reference so urce not found. summarizes the components of the Project.

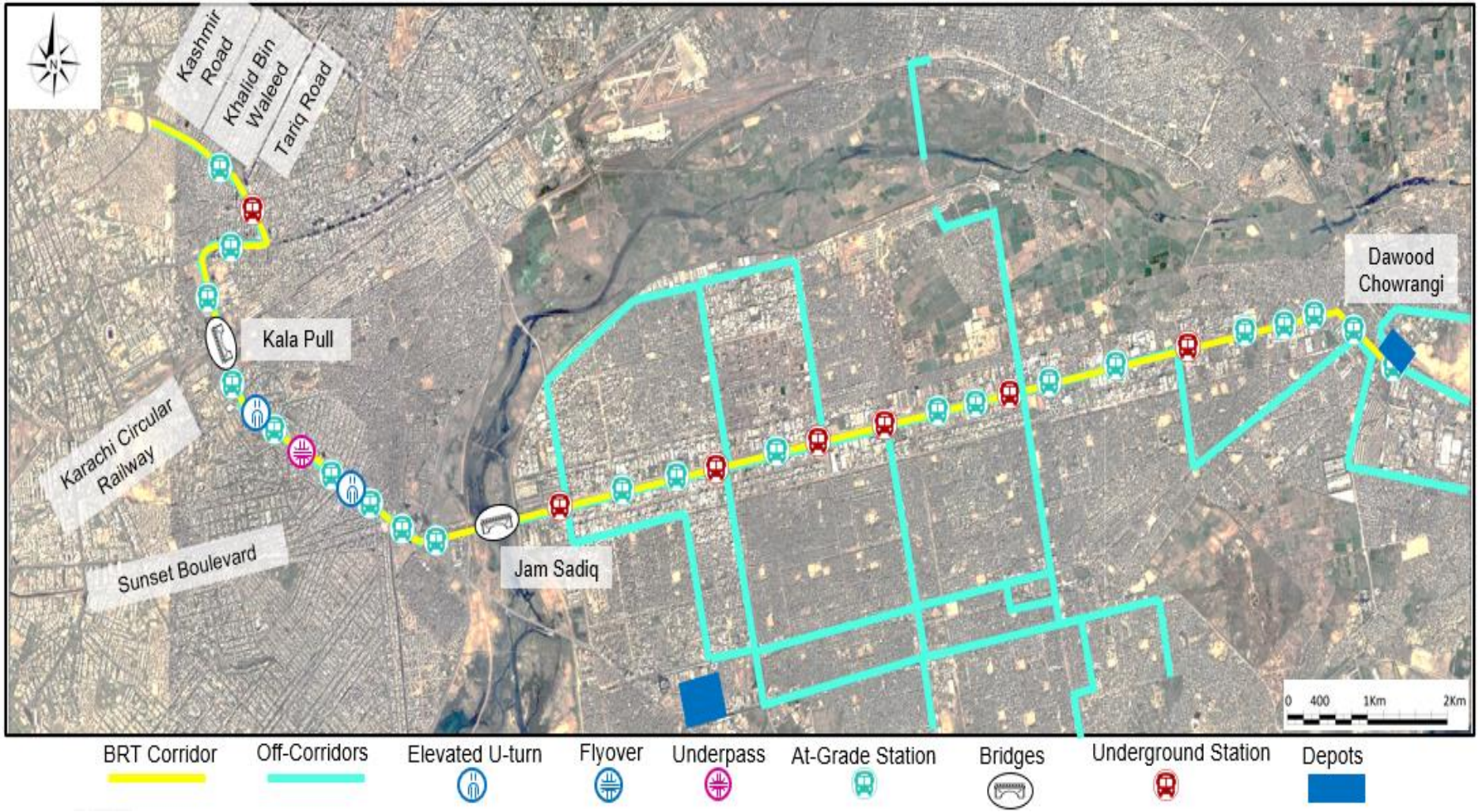


Figure 1-3: Yellow BRT Corridor and Project Components as per approved PC-1

Table 1-1: Project Components

Package	Segment	Length (km)	Area (Acres)	Under-ground Stations	At Grade Stations	Elevated U-Turns	Under-passes	Bridges	Flyovers
Package 1	Depot 1	-	3	-	-	-	-	-	-
Package 2	Depot 2	-	24	-	-	-	-	-	-
Package 3	Road Corridor & BRT Infrastructure (segments 0,1 and 2)	12.1	-	6	12	-	-	-	-
Package 4	1 km long bridge (segment 3)	1	-	-	-	-	-	1	-
Package 5	Road corridor & BRT Infrastructure (segments 4,5,6 and 7)	7.8	-	1	9	2	1	1	1
Package 6	Off-Corridor Improvements	65	-	-	-	-	-	-	-
Total		**85.9**	**27**	**7**	**21**	**2**	**1**	**2**	**1**

2. DATA COLLECTION AND INFORMATION

2.1 DATA COLLECTION

Comprehensive and reliable data provides the basis for proper planning and design of project. Survey maps, satellite imageries, hydro-meteorological data, river flows and existing facilities information related to the project/study will greatly help in project planning studies. The readily available data and previous studies reports related to the project have been collected and further information and data will be collected from the concerned agencies.

Following data/ information was already available with Nespak data bank:

v. Satellite Imagery showing proposed layout of relocated flood protection bund on left side.
vi. Drawing showing proposed bridge location and relocated left flood protection bund.
vii. Hydrology and Hydraulic Study Report for Realignment of Existing Left Bank of Malir River at Korangi Causeway (January 2021) conducted for Feasibility Study and Transaction Advisory Services, 'Urban Road Initiatives in Karachi' (Sub Project 1: Link Road for Korangi).
viii. Report on Geotechnical Investigation for Malir River Expressway Karachi, NESPAK Lahore.
ix. “Feasibility/ Viability Study Report”, Survey, Feasibility Study and Design for Realignment of Bund from Northern Side of Malir River, NESPAK, August 2013.
x. “Feasibility Report Karachi Flood Control Plan”, WAPDA, Sunny View, Lahore, November 1990.

For the Yellow Line BRT corridor study, topographic survey of the study area (u/s & d/s) and hydrological study analysis has already been carried out by NESPAK in November 2020. Data collected from previous studies and additional data gathered during present study (given below) has been used for the development of HEC-RAS Model. For carrying out the initial scour analysis, value of d50 has been taken from the previous report while updated geotechnical parameters have been used in the Model.

2.2 ADDITIONAL DATA

Following additional data has been collected for the completion of tasks mentioned in Chapter-1:

- BRT Yellow Line Malir River Bridge, kmz.
- “Final Preliminary Design Drawings”, Volume I, Updated Design and Cost Estimates Karachi Urban Mobility Project, NESPAK, December 2019.

- Bridge Structure Drawings, pdf.
- "Karachi Urban Mobility Project", Final Report BRTS Yellow Line, December 2019.

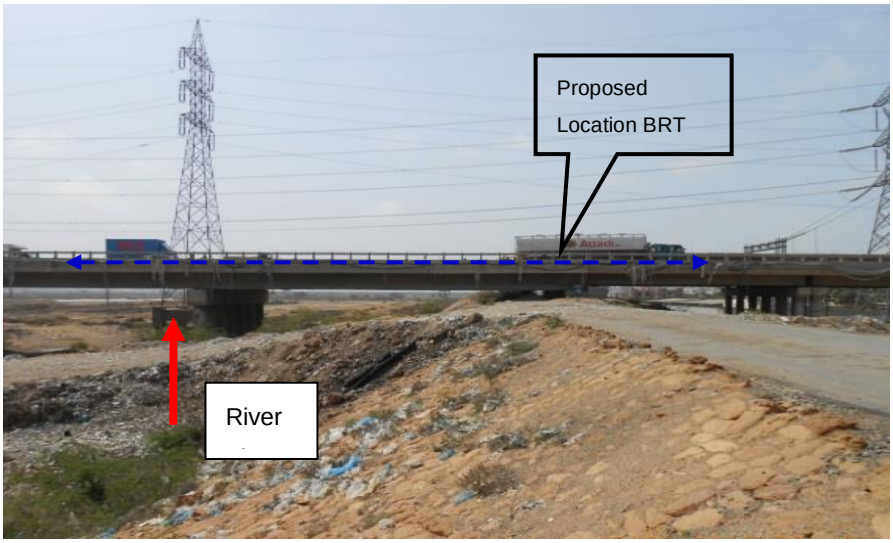
2.3 MEETING, FIELD VISITS OF STUDY AREA AND PHOTOGRAPHS

On August 11-13, 2020, teams of experts of NESPAK held meeting and visited the project area along Malir River from EBM Causeway to downstream PARCO Elevated Oil Pipeline. Proposed location of BRT Corridor upstream of JSB was also visited.

Photographs taken during the field visits are presented below:

Flood Plain View of Malir River

View of Left Embankment Upstream of EBM Causeway



JSB from Up-Stream Yellow Line BRT Corridor/ Bridge of Malir River

3. TOPOGRAPHIC SURVEY OF THE STUDY AREA[1]

3.1 LOCATION & EXTENTS OF THE PROJECT SITE

NESPAK Survey team carried out the cross sectional and topographical survey, as required for the proposed interventions (Korangi Road Bridge). Survey has been carried out in the months of July & August, 2020 in a reach starting from about 800 meters U/S of EBM causeway (Falcon Complex Area) and extending up to downstream of NIP/ PARCO Elevated Oil Pipeline near sea (Reach upstream EBM Causeway area - upstream & downstream of JSB - Korangi Causeway area - downstream of National Industrial Park (NIP)/ PARCO Pipeline). Total length of the study reach is about 6.6 km. Survey team has gathered the information and conducted relevant survey activities in the field. The team collected the cross-sectional data of the river in dry bed only. Most of the bathymetric part of survey could not be carried out due to slushy conditions. However, some patches of river bed, having comparatively less slush, were surveyed by using the rod technique.

A fresh topographic survey was conducted in 2021 by NESPAK team for YBRT project, covering only the route of the road. From this survey data river cross sections for HECRAS model could not be extracted. Its level comparison at four control points revealed that the bench mark of the survey in 2020 was 3.1 m higher than that selected for the survey in 2021. And this difference is due to difference of elevation datum, current survey (2021) was carried out using datum reference i.e. Survey of Pakistan (SOP). While the previous survey (2020) was carried out using UTM.

[1] - This survey was carried out for proposed Korangi Road Bridge replaced the existing Korangi Causeway 600 m downstream of JS Bridge. The same topographic survey has been used/ developed for mathematical Model HEC-RAS for proposed Yellow Line BRT Corridor construct just upstream of JS Bridge.

[2] - "Hydrology and Hydraulic Study Report for Realignment of Existing Left Bank of Malir River at Korangi Causeway", January 2021 conducted for Local Government & HTP Department GoS Under Feasibility Study and Transaction Advisory Services, 'Urban Road Initiatives: Link Road to Korangi'

3.2 SCOPE OF SURVEY WORK

Scope of survey work carried out (July & August 2020) mainly included the following;

- Reconnaissance visits of the project area.
- Establishment of survey Bench Marks (BM) in the area.
- Carry out topographic survey work from EBM Causeway to NIP (near sea).
- Preparation of inventory of existing structures.
- Processing of the observed data.
- Preparation of topographic survey map of project area.

The above-mentioned scope of the work has been completed by using the methodology, detailed as given in **Annexure A** of this report**.**

4. HYDROLOGICAL STUDIES

4.1 OBJECTIVE OF HYDROLOGICAL STUDY REPORT

The aim of this Hydrological Study Report is to estimate the design discharges at the cross-drainage locations along the proposed alignment. It has been inferred after a thorough review of the proposed alignment, there is one major cross drainage of Malir River which is located at just upstream to the existing JSB. The sole objective of the hydrological study report is to estimate design discharge of the bridge.

4.2 MALIR RIVER

Malir River is formed by the confluence of Mol and Khadeji tributaries, the catchment area of which are 611 km^2 (235 $mile^2$) and 567 km^2 (219 $mile^2$), respectively, whereas total catchment area up to its estuary is 2,314 km^2 (893 $mile^2$). After the confluence of Mol and Khadeji, the Malir River traverses through Karachi city about 43 km (27 mile) and outfalls into the Arabian Sea. The catchments of Mol and Khadeji are generally mountainous and mostly comprise of barren hills of low to medium height consisting of pale coloured limestone contains alluvial deposits, boulders, gravel and sandy clays. Whereas the lower part of the catchment mostly comprises of fully developed & underdeveloped urban area and cultivable area along the river banks.

4.3 REVIEW OF PREVIOUS STUDIES

4.3.1 Feasibility Report of Karachi Flood Control Plan - 1990

The study was conducted by Hydro Electric Planning Organization (HEPO) of WAPDA with the objective of designing of flood protection works for Karachi against inundations from Malir and Lyari rivers. For estimation of rainfall retention 0.1" was considered as consistent per hour losses during the storm whereas for the first increment this rate was enhance to 0.3". The 100-year 36-hr and 1,000-year 36-hr point rainfalls were estimated as 19.3" and 24.2", respectively.

The study estimated discharges of Mol and Khadeji Rivers against 100-year and 1,000-year return periods as 6,655 m^3/s (235,000 ft^3/s) and 9,118 m^3/s (322,000 ft^3/s) at their confluence point, respectively, whereas the 100-year discharge at the Malir River mouth was estimated as 409,000 ft^3/s (11,580 m^3/s).

Besides, Probable Maximum Floods (PMFs) were also estimated using phenomenon based Probable Maximum Precipitation (PMP) approach.

PMP depths were estimated after identification of 19-22 July 1913 storm as most critical storm, therefore, maximized by a moisture maximization factor (1.25) to arrive at PMP depths for the Malir River. The depth-area-duration relationship of observed 1913 storm is given **Table 4.1.**

Table 4-1: Depth-Area-Duration Relationship for Mol & Khadeji Rivers (mm)

Area ($mile^2$)	6-hr	12-hr	18-hr	24-hr	30-hr	36-hr
10	264	371	445	468	497	519
50	260	362	434	458	488	511
100	258	358	429	453	482	503
150	255	354	425	448	477	498
200	251	350	420	443	472	493
216	250	349	419	442	471	491
235	249	347	418	441	469	489

HEPO (1990) recommended construction of flood protection bunds along the Malir River into two stages i.e. stage I, flood protection against 1978, the highest observed flood peak of 6,230 m^3/sec (220,000 ft^3/sec) while for Stage II, further raising of the flood protection bunds, ultimately for 100-year flood of 11,580 m^3/s (409,000 ft^3/s).

4.3.2 Survey, Feasibility and Detail Design for Re-Alignment of Bund from North Side of Malir River (NESPAK 2013)

The Consultants carried out hydraulic modelling study of the river form RD 41+000 to RD 55+000; Korangi cause-way also lies in this reach. The hydraulic model was calibrated for the 1978 event and simulated for 100-year flood to estimate the flood levels. The 100-year flood estimated by HEPO-1990 (11,580 m^3/s) was adopted.

4.4 DATA COLLECTION

The observed discharge data of Malir River is available for the eleven years (1976-1986) at Super Highway Bridge, the gauge was operating by the Surface Water Hydrology Project (SWHP) of WAPDA. The observed annual instantaneous peak discharges during the period are shown in **Figure 4.1.**

The eleven years' period is an insufficient length for the estimation of 100-year flood peak. Therefore, rainfall-runoff modelling approach has been adopted for estimation of floods of various frequencies. Long-term daily rainfall time series for Karachi Masroor for the period 1970-2013 & 2018-2020 was collected from Pakistan Meteorological Department (PMD). The annual series of One-Day annual maximum rainfall is shown in **Figure 4.2.**

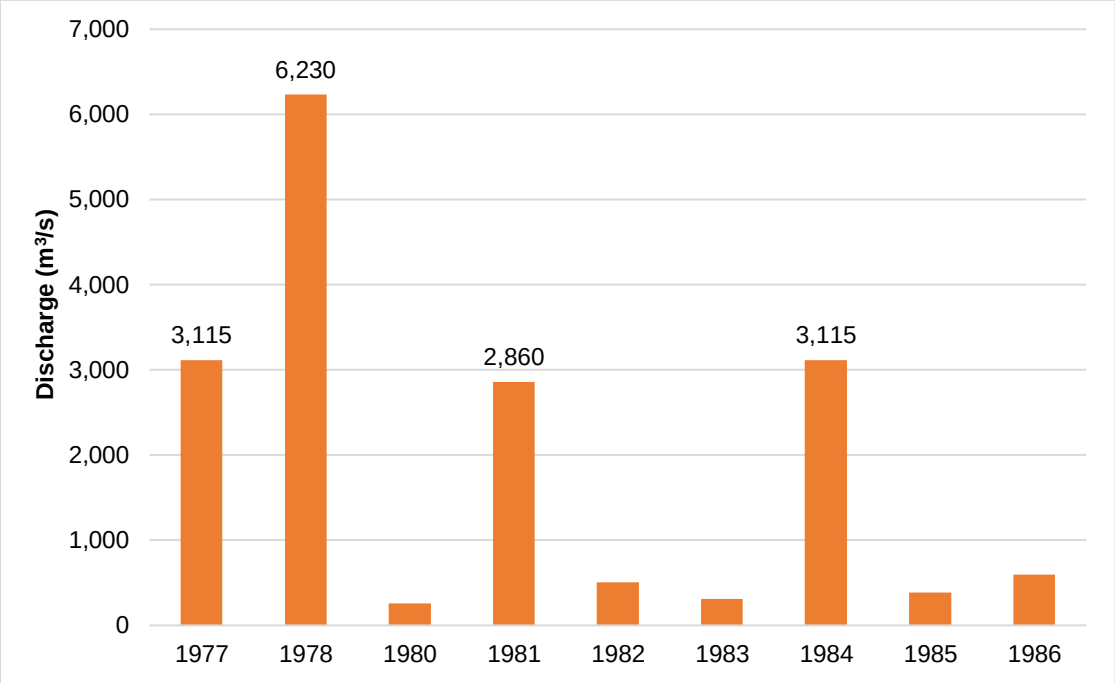


Figure 4-1: Annual Instantaneous Peak Discharges at Supper Highway Bridge

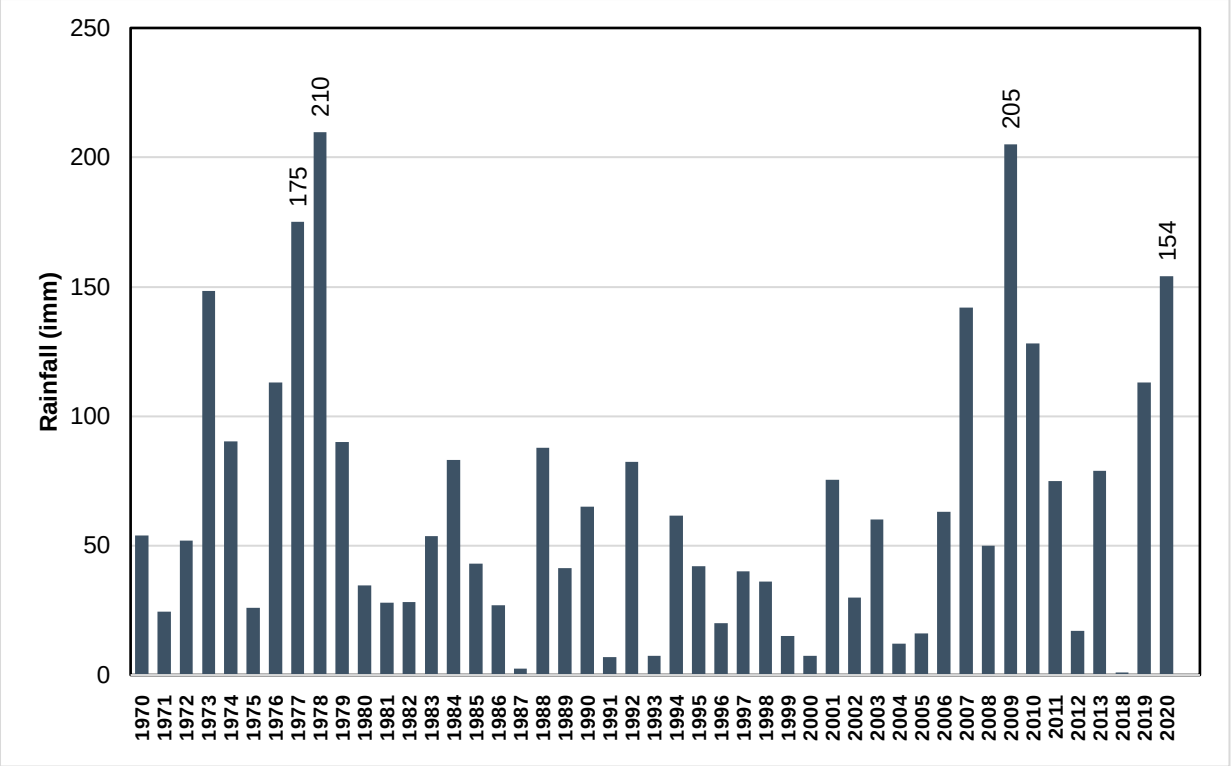


Figure 4-2: One-Day Annual Maximum Rainfall (Karachi Masroor)

Further, historic flood events in the project vicinity have also been collected from PMD and are given in **Table 4.2**.

Table 4-2: Maximum Rainfall of Extra-ordinary Storms in the Sindh Province

Sr. No.	Event Date	Rainfall (mm)	Rainfall (inches)	Station
1	18-23 July,1913	425	16.73	Thatta
2	1929 24-29 July	300	11.81	Near Tando Allah Yar
3	02-04 August, 1944	225	8.86	Karachi
4	30th June to 6 July, 1959	250	9.84	Malir
5	19-22 July, 1995	350	13.78	Khuzdar
6	25-28 June, 2007	250	9.84	Ormara
7	11-12 September, 2012	457	18.00	Jacobabad
8	25-27 August, 2020	368	14.49	Faisal base, Karachi

Observed rainfall depths of 25-27 August 2020 for Karachi city have also been collected and are given in **Table 4.3**. The 3-hourly data of only August 2020 extreme event is available of Karachi Airport station as given in **Table 4.4.**

Table 4-3: 25-27 August, 2020 Rainfall Event at Stations in Karachi

Sr. No	Station	Rainfall (mm)	Rainfall (inches)
1	Airport	212	8.0
2	Masroor	226	8.9
3	Landhi	228	9.0
4	Gulshan-e-Hadeed	173	6.8
5	North Karachi	218	8.6
6	Nazimabad	254	10.0
7	Saddar	230	9.1
8	Univeristy Road	189	7.4
9	Surjani Town	243	9.6
10	Faisal base	368	14.5
11	Kiamari Town	195	7.7

Table 4-4: 3-Hourly Observed Rainfall Depths (25-27 Aug 2020) at Karachi Airport

Date	Time	Rainfall (mm)	Date	Time	Rainfall (mm)
25/08/2020	0000z	1	26/08/2020	1200z	0
25/08/2020	0300z	7.1	26/08/2020	1500z	0
25/08/2020	0600z	5.7	26/08/2020	1800z	0
25/08/2020	0900z	65.7	26/08/2020	2100z	0
25/08/2020	1200z	7.7	27/08/2020	0000z	0
25/08/2020	1500z	0.7	27/08/2020	0300z	0
25/08/2020	1800z	0	27/08/2020	0600z	5
25/08/2020	2100z	0	27/08/2020	0900z	70
26/08/2020	0000z	0	27/08/2020	1200z	3
26/08/2020	0300z	0.8	27/08/2020	1500z	32
26/08/2020	0600z	0	27/08/2020	1800z	11.9
26/08/2020	0900z	2.1	27/08/2020	2100z	0

4.5 DATA ANALYSIS

4.5.1 Design Hyetograph

Frequency Analyses

100-year rainfall depths have been estimated by frequency analyses of One-Day annual maximum rainfall series. The frequency analyses have been carried out using Gumbel's EV Type-I distribution. Plotting positions has been computed by Weibull's formula as shown in Figure 4.3. The rainfall depths of various return periods are given in **Table 4.5**.

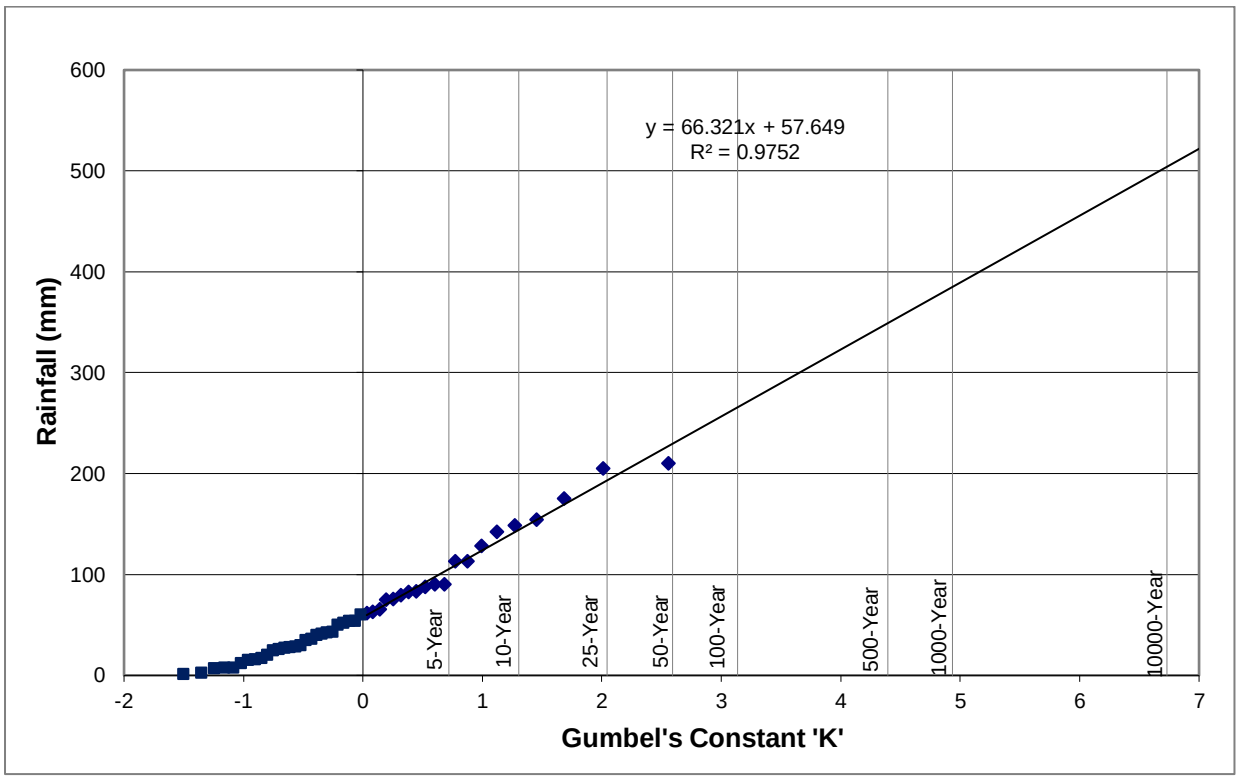


Figure 4-3: Plotting Positions and Fitted Line to One-Day Annual Maximum Rainfall Depths

Table 4-5: One-Day Rainfall Depths of Various Return Period at Karachi Masroor

Return Period	Rainfall Depth (inches)	Rainfall Depth (mm)
2.33	2.3	58
5	4.2	107
10	5.7	145
25	7.6	193
50	9.0	229
100	10.5	267

Source: PMD Gauge Station at Karachi Mansoor

Time Distribution for Design Storms

The 3-hourly data of only August 2020 extreme event is available at Karachi Airport station. In the first step, a 24-hr duration with maximum rainfall has been sorted and subsequently used in the estimation of design hyetograph. The 24-hr maximized rainfall distribution is shown in **Figure 4.4**.

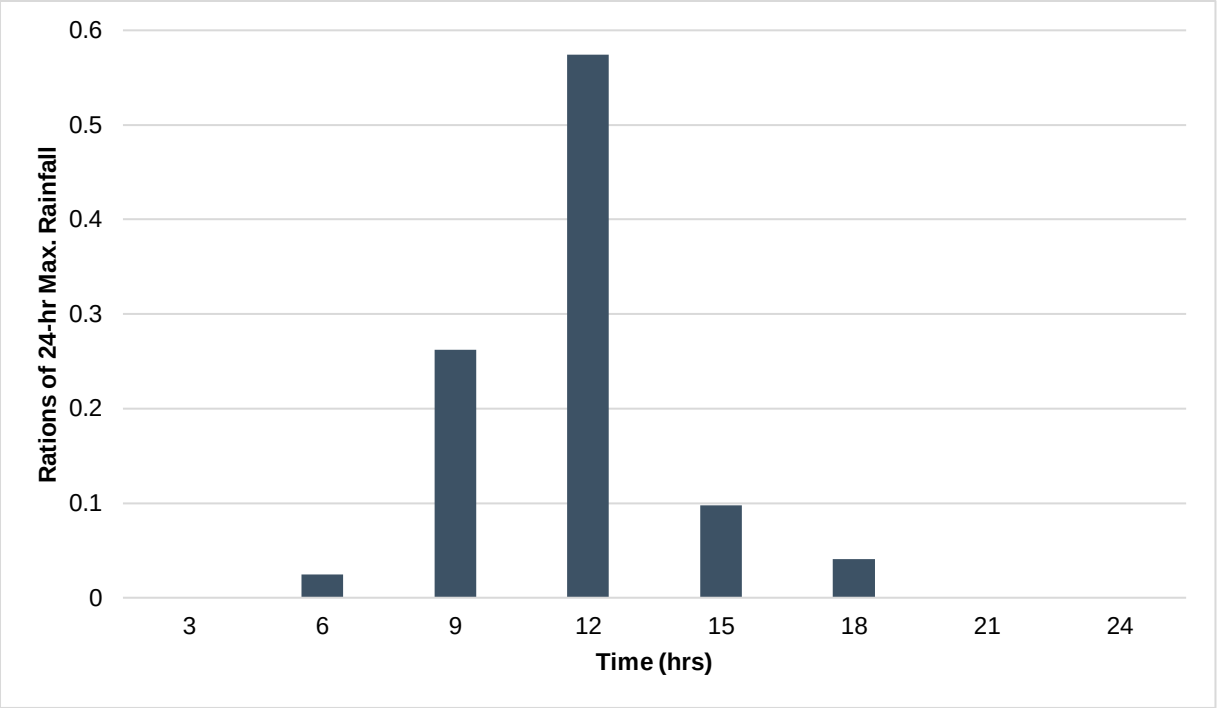


Figure 4-4: 24-hr Maximized Time Distribution of August 2020 Event

One-Day to 24-hr Rainfall Conversion Factor

The precipitation depths are usually reported against a fixed time interval e.g. for daily data, a day supposedly complete at 8:00 am daily. Hershfield (1961) suggested to multiply a factor 1.13 with the results of frequency analysis of one-day annual maximum rainfall depths for a single fixed time interval to obtain true maxima. Therefore, one-day 100-year rainfall depth (267 mm) has been converted in to 24-hour rainfall depth with a factor 1.13 (267x1.13 = 302 mm).

Point to Area Reduction Factor

It has been observed that in extraordinary storm events the rainfall depths have substantial areal reduction from the centre of the storm. In this context, Halcrow (1986) estimated a generalized curve using the observed data of storm events in the vicinity of the catchment area, as shown in **Figure 4.5**. The Figure 4.7 and catchment area of Malir River (893 mile^2) provides a point to area reduction factor of 0.81 and subsequently 100-year 24-hr point rainfall depth (302mm) has been reduced to 245 mm.

Figure 4-5: Point to Area Reduction Curve for the Rainfall Event (Halcrow 1986)

100-year 24-hr Design Hyetograph

The rainfall distribution (Figure 4.2) has been applied to 100-year 24-hr basin rainfall (245 mm). The 100-year design hyetograph for the Malir River at the Bridge Site is shown in **Figure 4.6.**

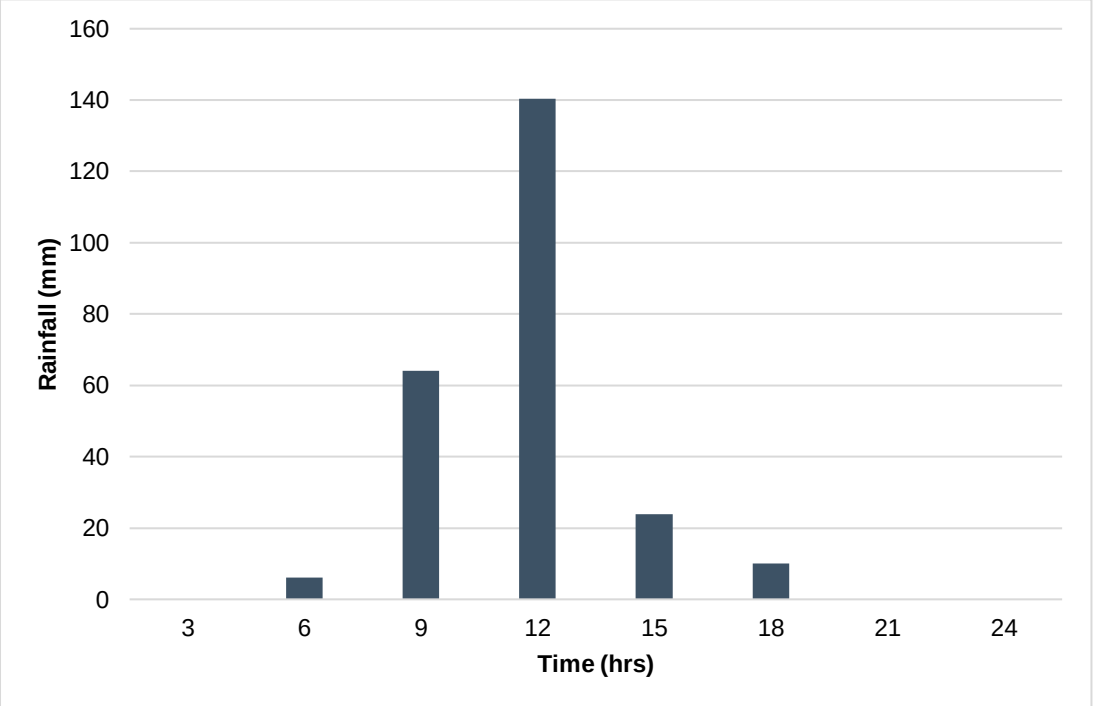


Figure 4-6: 100-year Design Hyetograph for The Malir Basin at Bridge Site

4.5.2 Estimation of peak discharges

Catchment characteristics

The catchment characteristics of the area such as soil cover, land use, soil type and extents affect the runoff generation potential. These parameters have been investigated using public domain satellite imageries as well as from field/catchment visit. The natural slope and drainage network in the vicinity of project area have been determined from topographic maps and Digital Elevation Model (DEM) of Shuttle Radar Topographic Mission (SRTM). The United States Natural Resources Conservation Method (USNRCS) Curve Number (CN) method has been selected for the estimation of runoff depth.

Soil

In USNRCS method, soils are classified in four groups called Hydrologic Soil Group A, B, C and D. Group A corresponds to highly permeable soils with low runoff potential while group D corresponds to highly impermeable soils. Group B and C soils are of intermediate properties. It was observed during the site visit that silty clay/clayey silt material exists on the ground strata, whereas upper catchment is mountainous rarely with thin layer of overburdens which makes the catchment in soil group B & C with low to moderate permeability properties.

Cover

The type of cover also influences the amount of runoff. The cover of lower part of the catchment consists of agriculture fields along the river, fallow land and urban area “developed & underdeveloped”, whereas upper part mainly consists of barren mountains and their toe area consists of scattered plots of fallow land. Therefore, a small fraction of the lower part of the catchment has been placed in to fair hydrologic condition with vegetation cover between 50%-75% and entire upper catchment of Mol and Khadlji Rivers has been placed in to poor hydrologic condition with vegetation cover less than 50%.

Selection of Curve Number

Equivalent hydrologic soil group has been found for every soil and the curve number selected for each soil, keeping in view future land use of the project area. Vegetation and land use has been determined by the field visit and Landsat 8 data. The Malir River basin has been divided in to twenty-eight (28) sub-basins for the hydrologic modelling in the HEC-HMS (Hydrologic Engineering Center – Hydrologic Modelling System) model, the Malir River basin and 28 sub-basins are shown in **Figure 4.7**. The curve numbers for the 28 sub-basins have been selected as given in **Table 4.6**.

Table 4-6: Selection of Curve Numbers for the Sub-basins

Name	Area (Km^2)	Area of Major Land Uses (Km^2)				Curve Number
		Cultivable	Barren Hills	Urban	Floodplain	
SB01	79	8	71	-	-	87
SB02	62	3	59	-	-	87

Name	Area (Km^2)	Area of Major Land Uses (Km^2)				Curve Number
		Cultivable	Barren Hills	Urban	Floodplain	
SB03	63	44	19	-	-	87
SB04	122	18	104	-	-	87
SB05	107	3	104	-	-	87
SB06	60	2	58	-	-	87
SB07	117	12	105	-	-	87
SB08	69	37	32	-	-	87
SB09	80	61	18	1	-	87
SB10	52	39	14	-	-	87
SB11	90	50	40	-	-	87
SB12	98	78	21	-	-	87
SB13	51	-	51	-	-	87
SB14	99	2	82	15	-	87
SB15	117	40	64	13	-	87
SB16	78	-	34	44	-	86
SB17	111	64	-	28	20	85
SB18	98	33	43	22	-	87
SB19	88	72	-	16	-	87
SB20	67	9	41	17	-	87
SB21	122	2	119	-	-	87
SB22	54	25	26	3	-	87
SB23	75	33	12	30	-	87

Name	Area (Km^2)	Area of Major Land Uses (Km^2)				Curve Number
		Cultivable	Barren Hills	Urban	Floodplain	
SB24	88	-	-	82	6	85
SB25	85	6	23	56	-	86
SB26	78	21	9	48	-	87
SB27	27	-	-	21	6	83
SB28	66	-	-	62	4	85
Total	**2,303**	**661**	**1,148**	**459**	**36**	**87**

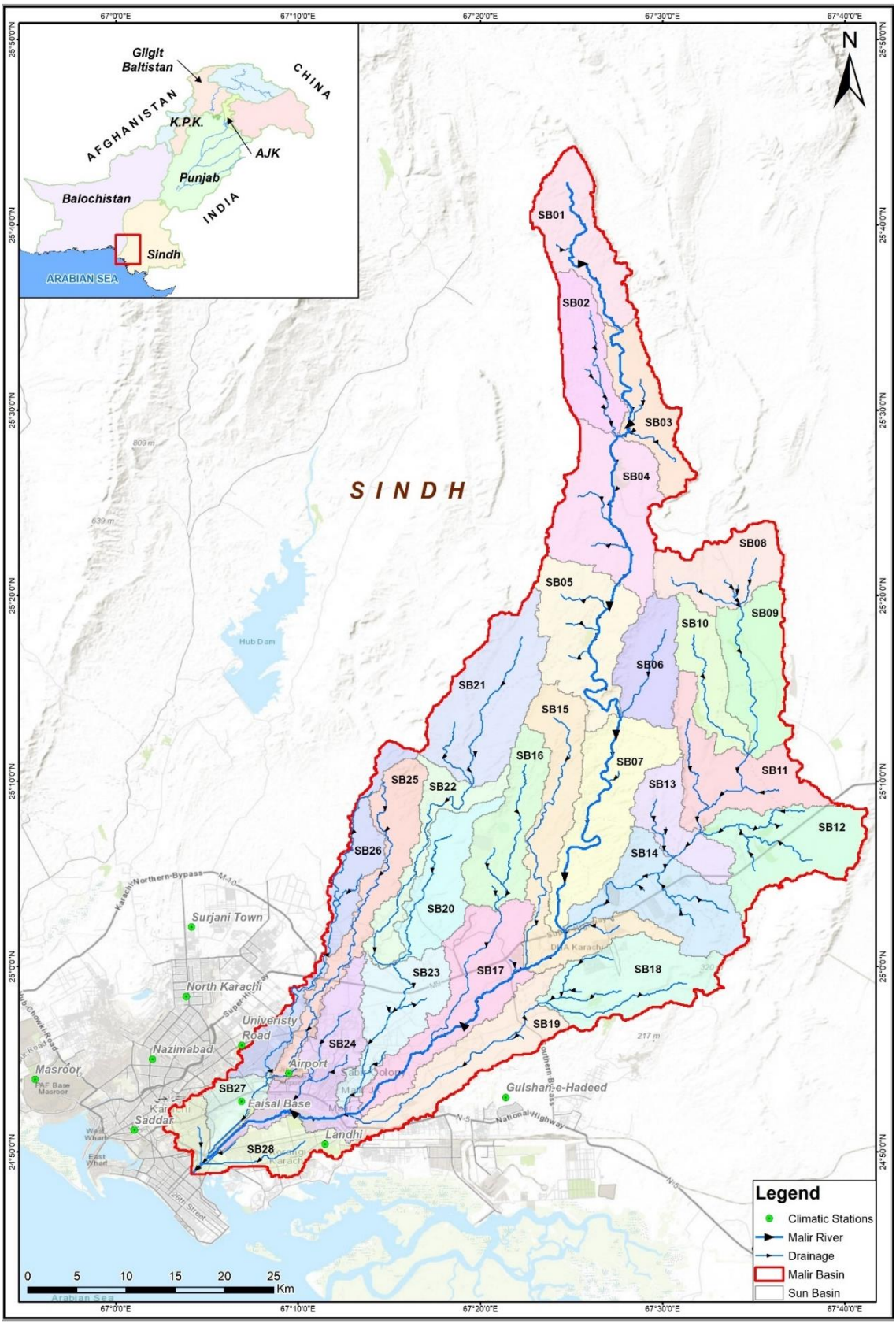


Figure 4-7: 100-year Design Hyetograph For The Malir Basin at Bridge Site

Time of Concentration

Bransby-Williams' formula[2], recommended for large watershed, has been used for the estimation of time of concentration (Tc) of sub-basins. The formula is given in equation 1. The Time of concentrations of 28 sub-basins are given in **Table 4.7**.

$$\mathbf{Tc = 58.5LA^{-0.1}S^{-0.2}}$$ **----------Equation-1**

Where,

T_c = Time of Concentration (minutes)

L = Length of the Longest Stream (km)

A = Catchment Area (km^2)

S = Equal Area Slope (m/km)

Table 4-7: Time of Concentration of the Twenty-Eight Sub-Basins

Name	Area (km^2)	Length (km)	Slope (m/km)	Tc (minutes)
SB01	79	24	9	584
SB02	62	21	8	540
SB03	63	17	6	454
SB04	122	20	7	490
SB05	107	29	5	771
SB06	60	16	9	410
SB07	117	35	7	881
SB08	69	12	8	313

[2]Estimating time of concentration in large watersheds by E. Taghvaye Salimi et. al., Paddy Water Environ (2017) 15:123–132

Name	Area (km^2)	Length (km)	Slope (m/km)	Tc (minutes)
SB09	80	21	5	578
SB10	52	20	6	541
SB11	90	20	6	522
SB12	98	18	9	428
SB13	51	13	15	301
SB14	99	25	6	648
SB15	117	35	7	876
SB16	78	21	11	494
SB17	111	29	4	802
SB18	98	22	8	526
SB19	88	28	4	812
SB20	67	24	10	583
SB21	122	23	8	550
SB22	54	32	8	836
SB23	75	23	4	645
SB24	88	23	3	683
SB25	85	37	6	948
SB26	78	41	6	1076
SB27	27	10	2	387
SB28	66	15	2	513

Estimation of peak discharges

HEC-HMS model has been used for the estimation of peak discharges. The catchment has been divided in to twenty-eight (28) sub-basins interconnected through sixteen (16) reaches and fifteen (15) junctions. The NRCS dimensionless unit hydrograph method has been selected as runoff transform method whereas NRCS CN method has been selected as rainfall loss method. The schematic layout of HEC-HMS model is shown in **Figure 4.8.**

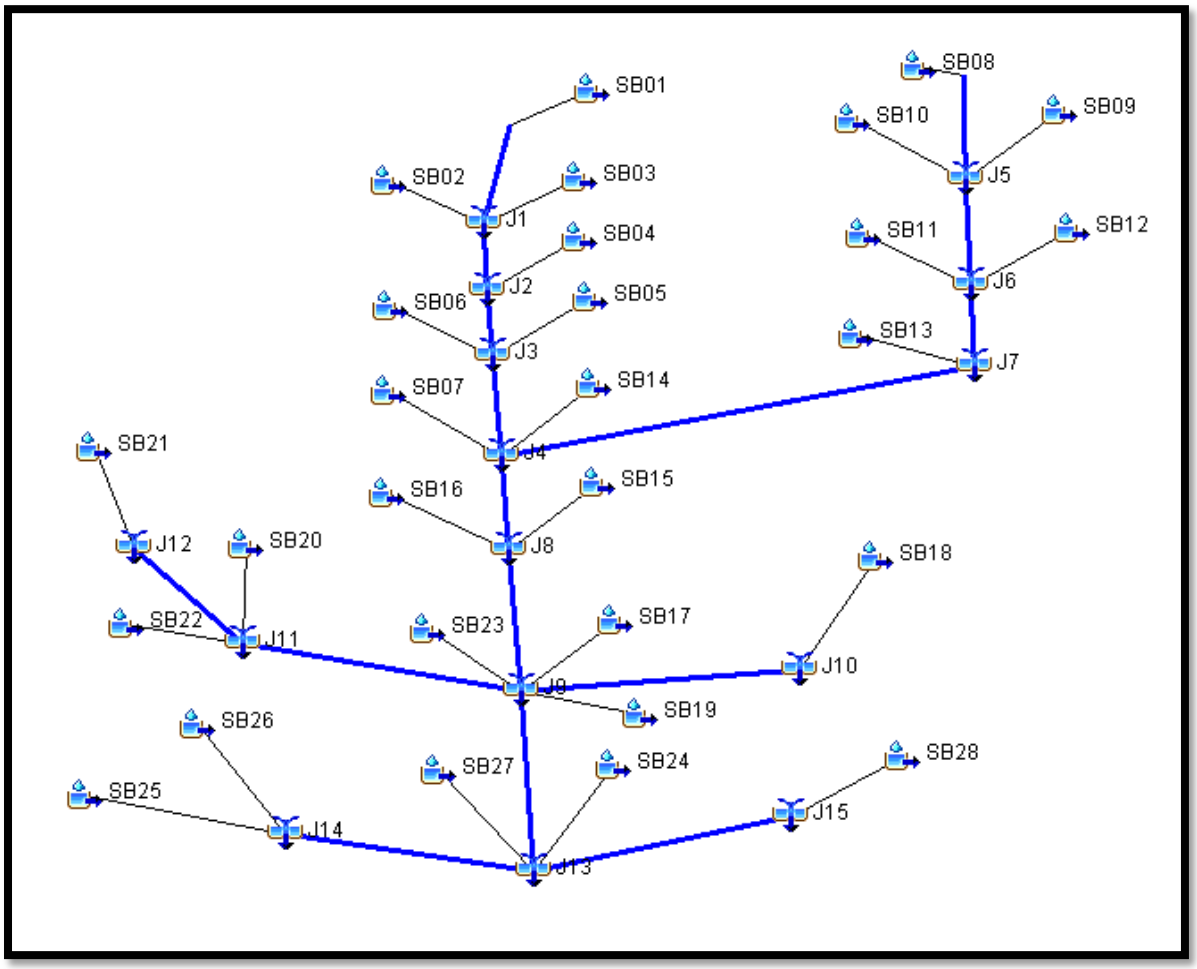


Figure 4-8: Schematic Layout of Malir River in HEC-HMS Model

The 100-year 24-hr rainfall hyetograph (Figure 4.4) has been simulated in HEC-HMS model. Considering the time of concentration of various sub-basins, the time step of model control specifications has been set to 30 minutes. The model has provided a peak discharge 10,950 m^3/s at the Bridge Site.

4.6 CONCLUSION AND RECOMMENDATIONS

- The annual instantaneous peak discharge data of Malir River at super highway bridge is available for the period 1976-1986 (11-years), which is an insufficient data length for flood frequency analysis, whereas flood frequency analysis requires minimum 30-years data of recent years.

- Historic rainfall records and corresponding details of 1913 storm (required for verification of HEPO-1990 analysis) were not available with PMD. Further various hydrological parameters required to reproduce HEPO-1990 flood peak were not available in respective report.
- The historic highest instantaneous peak flood of 6,230 m^3/s was observed in 1978 at super highway bridge by SWHP of WAPDA.
- The 100-year One-Day rainfall depth has been estimated as 267 mm at Karachi Masroor station, which produced a flood peak of 10,950 m^3/s (387,000 ft^3/s).
- The estimated 100-year flood peak is consistent with earlier estimate of 409,000 ft^3/sec (11,580 m^3/s) of HEPO-1990 (5% higher than the present study) and therefore, recommended as the 100-year design flood for the Yellow Line Bridge on Malir River.

5. DETAILED ENGINEERING DESIGN

5.1 MATHEMATICAL MODEL

To estimate the hydraulic impact of the proposed bridge (650 m long and about 40 m u/s of JSB), in terms of the change in water surface profile on the u/s reach, a 1- dimensional mathematical model was developed by employing HEC-RAS software; which is developed by the US Army Corps of Engineers (USACE).

The model takes into account the river geometry in terms of cross-sections. The u/s boundary is defined at the most u/s x-section, and the d/s boundary is defined at the most d/s x-section.

Resistance to the flow has been modelled by Manning's roughness coefficients for the main river creak and flood plains, based on the professional judgment for such river conditions as observed during the site visit for Korangi Bridge Project. The program computes water level at all cross-sections and thus produces a water surface profile for the modelled reach.

5.2 INPUTS FOR MATHEMATICAL MODEL

5.3.1 Design Discharge

The design discharge of the proposed bridge has been fixed as the 100-year return period flood discharge; which is a common practice for bridge design over rivers in Pakistan. The 100-Year discharge has been estimated as 409,000 ft^3/s (11,580 m^3/s), as described in Chapter 4 of this report.

Figure 5-1: Layout of Existing Structures and Proposed Corridor

5.3.2 River Reach

The studied river-reach is 6.6 km long. The u/s end of the reach is 1 km beyond the EBM causeway, and the d/s end is at Parco Oil Pipeline. The existing JSB has been incorporated as an inline hydraulic structure in the model. On the d/s of JSB, there exists Korangi Causeway at a distance of 600 meters. **Figure 5.2** shows the layout plan of the study reach.

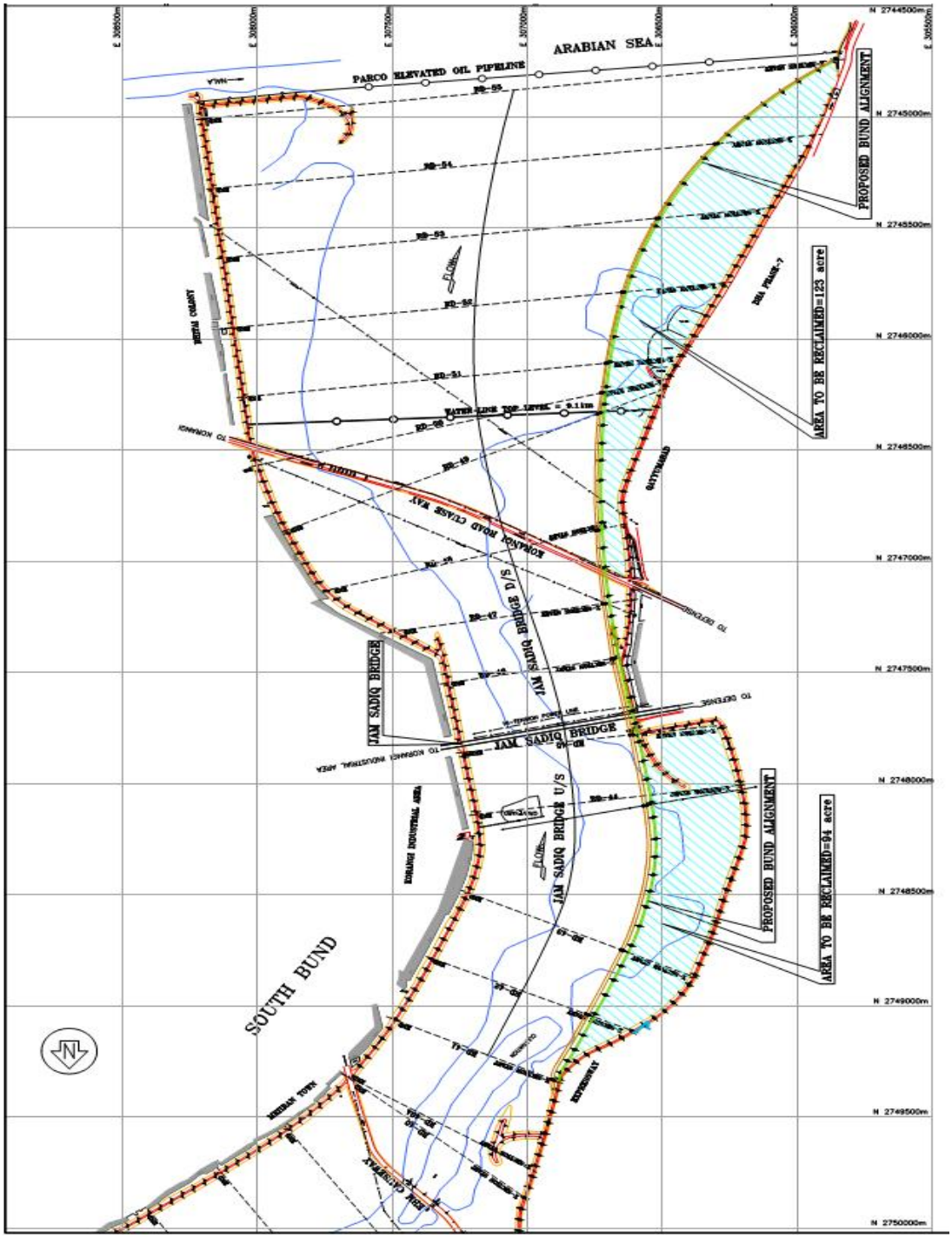


Figure 5-2: Malir River Study Reach

EBM Causeway, JSB, and Korangi Causeway are three successive locations in the study reach, which are currently being used for crossing the river during the dry period. During the rainy season, causeways are abandoned and only the JSB could be used; which creates traffic problems in the area. At Korangi Causeway, a project has already been conceived for the construction of Korangi Bridge and relocating the left bank toward the riverside. A major sewerage nullah discharges into the river from the left bank at a location where Parco Oil Pipeline crosses the river over pedestals.

River reach has been examined in detail using satellite images and Geographical Information tools to observe the extent of the flood plain and meandering of the river.

5.3.3 River Cross Sections

Total thirty-three (33) cross-sections (including the one at bridge location) at varying intervals have been used to develop the mathematical model. Locations of the cross-sections are shown in **Figure 5.3.** Survey team was mobilized (July to August 2020) to gather the information and conduct relevant surveys in the field. The team collected the cross-sectional data of the river in dry bed. The bathymetric part of the survey could not be carried out due to slushy conditions. However, some patches of river bed, having comparatively less slush, were surveyed by using the rod technique. In this regard, freely available elevation data of Shuttle Radar Topography Mission (SRTM) was also used (with prior calibration) with the field-collected data. The final data set was prepared by using a hybrid approach; i.e. combination of field-collected data and SRTM data. The data was then converted into Digital Surface Model (DSM) for the computational stability in HEC-RAS model.

The surveyed cross-sections and the Digital Elevation Model (DEM) of the study reach are shown in **Figure 5.3** and **Figure 5.4**. Plots of the surveyed cross-sections are also provided in Annexure B.

5.3.4 Manning's Roughness Co-Efficient

The resistance to river flow depends upon the river morphology, bed material, vegetation, and man-made interventions in and along the flood plain. This feature is simulated by fixing the magnitude of Manning's roughness coefficient "n" in the model. Roughness is generally higher for over-banks as compared to the main creek.

Based on the site visit observations, it was decided to use two sets of n-values. For the cross-sections u/s of JSB, the n-value is taken as 0.030 for the main creek and 0.035 for the left and right over-banks. For the cross-sections d/s of JSB, the n-value is taken as 0.033 for the main creek and 0.043 for the left and right over banks. Summary of Manning's n-values is given in **Table 5.1**.

Table 5-1: Manning's Roughness Coefficient Used in Model

Location	Manning's Roughness Coefficient for Main Channel	Manning's Roughness Coefficient for Over Banks
Upstream Reach of JSB	0.030	0.035
Downstream Reach of JSB	0.033	0.043

5.3.5 Boundary Condition

The u/s boundary has been defined as a steady discharge of 409,000 cusecs, corresponding to the design discharge of 100 years return period.

The d/s boundary has been defined at the most d/s x-section (Parco Oil Pipeline) as a fixed water level, corresponding to the historic highest sea level (4.0 m tide). The value of high tide has been taken from the report "Pakistan Tide Table 2020".

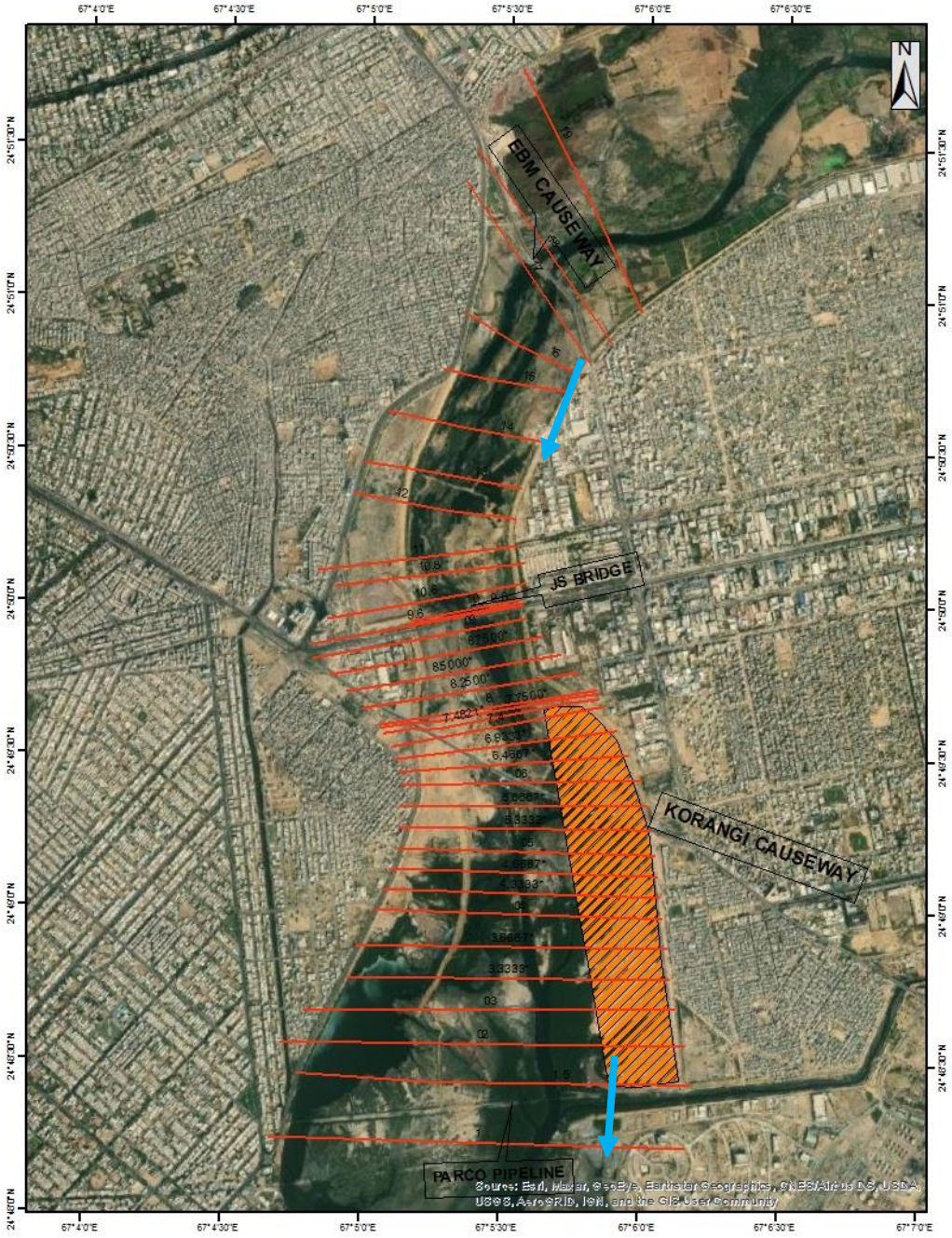


Figure 5-3: Layout Plan Showing Cross Section Lines

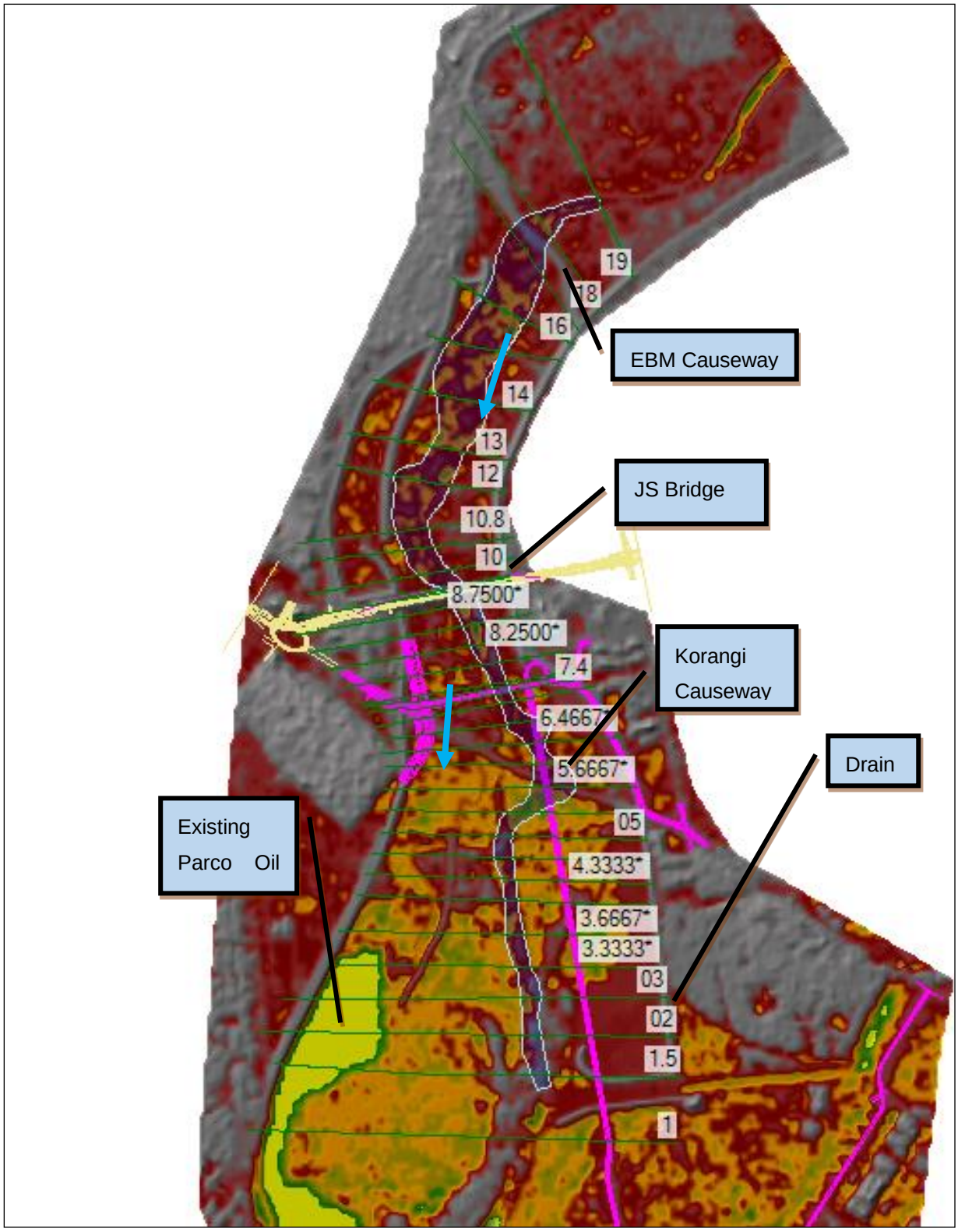


Figure 5-4: Cross Sections of the Study Reach

5.3.6 Freeboard

Freeboard is the vertical clearance above the design flood level. The model results indicate that the soffit level of JSB has a freeboard of more than 2 m. For the recently proposed Korangi Road Bridge, the freeboard was fixed as 2 m, as per the recommendation of the Federal Flood Commission. Therefore, freeboard of 2 m is recommended for the proposed YBRT Bridge.

5.3 RESULTS OF NUMERICAL MODEL STUDY

For the assessment of water surface profile, steady-state simulations at a discharge of 409,000 cusecs have been carried out for the following three (3) scenarios:

- ***Scenario 1****:* Existing / Base Conditions.
- ***Scenario 2****:* Proposed Yellow Line Corridor/ Bridge Without Any Other Proposed Interventions (Upstream and Downstream of JSB).
- ***Scenario 3****:* Proposed Yellow Line Corridor/ Bridge with All Proposed Works - Korangi Bridge Project Downstream Features/ Components.

5.3.1 Scenario 1: Existing / Base Conditions

Under this scenario, the HEC-RAS model has been simulated with the existing river infrastructure between the EBM causeway and the Parco Oil Pipeline. The only hydraulic structure is the JSB, which is introduced as an in-line structure. Its other relevant features are the embankments, levees, and ineffective areas that were incorporated accordingly. The simulated water surface profile is shown in **Figure 5.5**.

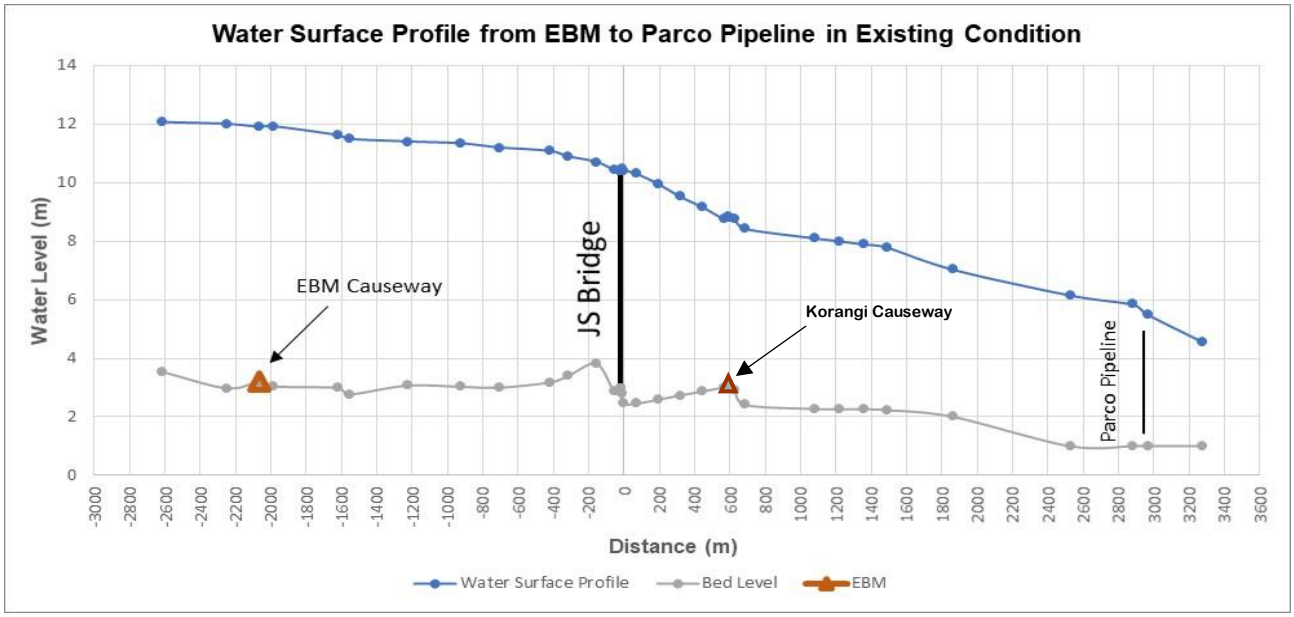


Figure 5-5: Water Surface Profile for Existing/ Base Condition

5.3.2 Scenario 2: Proposed Yellow Line Bridge Without any Proposed Interventions Works

Under this scenario, the HEC-RAS model has been simulated with the proposed Yellow Line Bridge, inserted 40m u/s of the existing JSB. However, the proposed Korangi Bridge project features (d/s of JSB) are not inserted.

The other river infrastructure is the same as included in the base condition scenario; which includes the existing EBM causeway, existing JSB piers, and the existing Korangi causeway. The simulated water surface profile is shown in **Figure 5.6**.

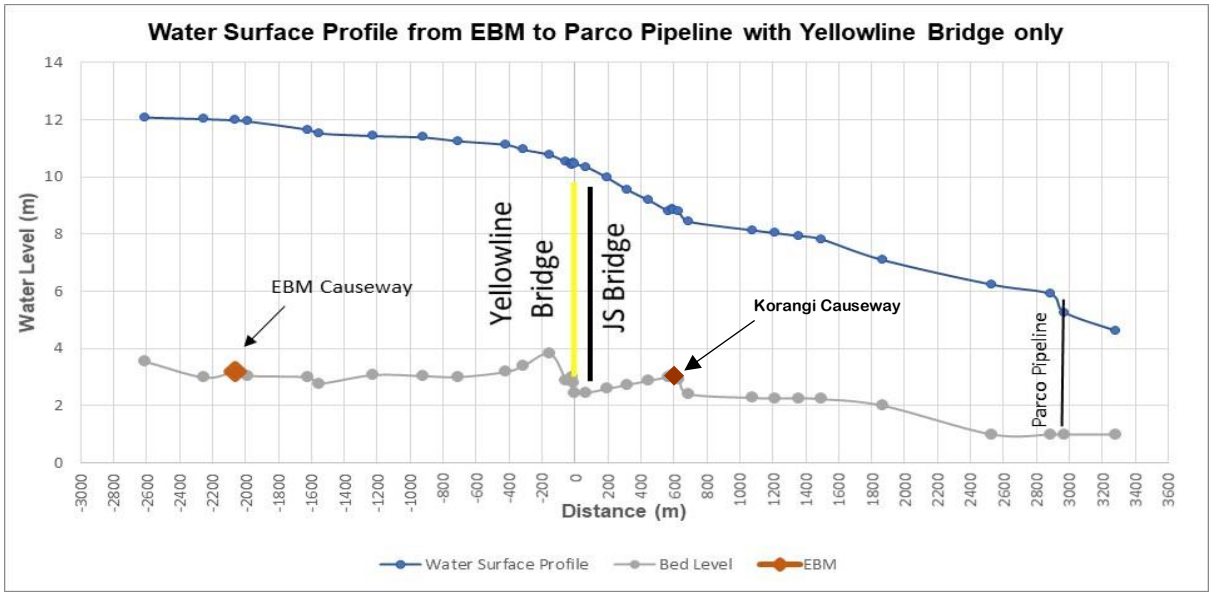


Figure 5-6: Water Surface Profile with Proposed Yellow Line Bridge

5.3.3 Scenario 3: Proposed Yellow Line Bridge with All Proposed Project Works (Korangi Bridge Project Features)

Under this scenario, the HEC-RAS model has been simulated with two proposed project features: (i) The proposed Yellow Line Bridge, and (ii) Another proposed project, namely Korangi Bridge. This scenario can be visualized in two perspectives: (1) The Korangi Bridge Project is already existing and the Yellow Line Bridge is to be constructed afterward. (2) The Yellow Line Bridge is constructed first, and Korangi Bridge Project is implemented afterward. The simulated water surface profile is shown in **Figure 5.7.**

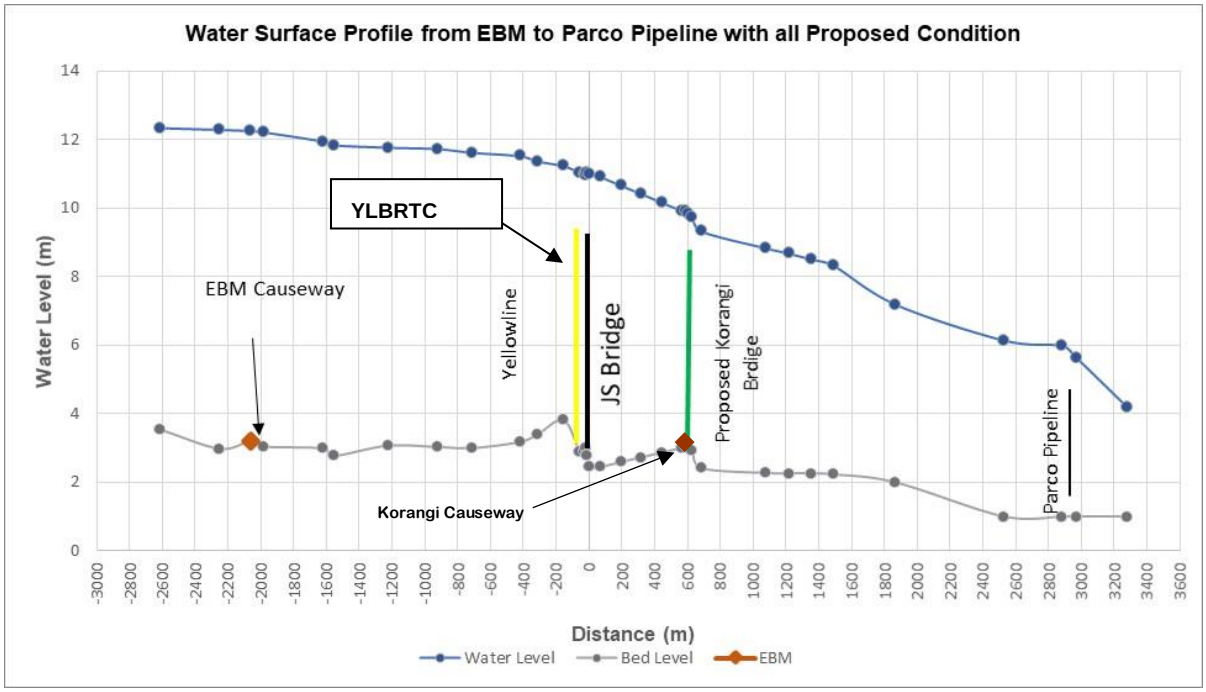


Figure 5-7: Water Surface Profile with Both Proposed Yellow Line Bridge (U/S) and Korangi Bridge Project (D/S) Features

A summary of the above-mentioned three (3) scenarios is given in **Table 5.2**.

Table 5-2: Simulation Results of Water Surface Profiles of Three (3) Scenarios

Sr. No.	Cross Section No.	Distance from JS Bridge (m)	Min Ch. Elev. (m)	Water Surface Elevation (m)		
				Base Conditions (Scenario 1)	Yellow Line Bridge (Scenario 2)	Yellow Line Bridge + Korangi Bridge (Scenario 3)
1	19	-2612	3.54	12.05	12.09	12.33
2	18	-2250	2.98	11.99	12.03	12.28
3	EBM	-2063	3.2	11.89	11.99	12.245
4	17	-1983	3.04	11.91	11.95	12.21
5	16	-1620	2.99	11.61	11.66	11.94
6	15	-1552	2.77	11.48	11.53	11.83

Sr. No.	Cross Section No.	Distance from JS Bridge (m)	Min Ch. Elev. (m)	Water Surface Elevation (m)		
				Base Conditions (Scenario 1)	Yellow Line Bridge (Scenario 2)	Yellow Line Bridge + Korangi Bridge (Scenario 3)
7	14	-1226	3.07	11.39	11.44	11.76
8	13	-924	3.03	11.33	11.39	11.71
9	12	-708	3	11.19	11.26	11.6
10	11	-418	3.18	11.07	11.13	11.5
11	10.8	-315	3.39	10.89	10.96	11.35
12	10.6	-154	3.82	10.7	10.78	11.21
13	10	-56	2.89	10.43	10.52	11.01
14	9.9	-26	2.89	10.4	10.45	10.995
15	9.8	-17	3	10.38	10.43	10.98
16	9.6	-10	2.8	10.47	10.51	11.04
17	9.5	0	2.45	10.41	10.45	11.0
18	9	69	2.45	10.3	10.35	10.92
19	8.750*	195	2.59	9.95	9.98	10.67
20	8.500*	317	2.73	9.52	9.55	10.43
21	8.250*	446	2.87	9.16	9.19	10.17
22	8	568	3.01	8.75	8.81	9.93
23	7.750*	591	3.07	8.83	8.88	9.92

Sr. No.	Cross Section No.	Distance from JS Bridge (m)	Min Ch. Elev. (m)	Water Surface Elevation (m)		
				Base Conditions (Scenario 1)	Yellow Line Bridge (Scenario 2)	Yellow Line Bridge + Korangi Bridge (Scenario 3)
24	7.5	600	3	8.805	8.84	9.85
25	7.482*	629	2.93	8.75	8.8	9.75
26	7.4	686	2.41	8.42	8.45	9.33
27	6	1078	2.27	8.1	8.14	9.2
28	5.667*	1217	2.26	8.0	8.04	9.02
29	5.333*	1356	2.26	7.89	7.94	8.84
30	5	1492	2.23	7.78	7.83	8.33
31	4	1867	2	7.03	7.1	7.2
32	3	2527	1	6.16	6.24	6.15
33	2	2884	1	5.84	5.91	5.99
34	Parco P/line	2969	1	5.5	5.265	5.65
35	1	3280	1	4.57	4.62	4.2

Elev. = Elevation, Min. = Minimum Ch. = Channel

Determination of Scour Depth

There are various methods for computing scour depth. Lacey's method and HECRAS methods are discussed below:

- By Lacey's Method

If the actual waterway "W (m)" is less than the Lacey's regime width "P" ($4.83*Q^{0.5}$), where P is in meter and Q is in m^3/sec, the potential scour depth "XR" depends on the discharge intensity "q", silt factor "f" (function of D_{50}), and scour factor "X" (as per the vulnerability of location). Potential scour depth is computed by the following equation:

$XR = X*(1.34 \times [q^2/f]^{1/3})$ ……. ……. (1)

Where as:

R = Scour depth below HFL (m)

q = Discharge per unit width (m^3/sec)

f = Lacey's silt factor = $1.76*(D_{50})0.5$

D_{50} = Average grain size (mm)

X = Scour Factor (2 for pier nose)

When the actual waterway is greater than the Lacey's regime width (present case), the potential scour depends on the total discharge Q, silt factor f, and scour factor X.

$XR = X* 0.475 \times [Q/f]^{1/3}(m)$ …….(2)

Where as:

X = Scour Factor

Q = Total Discharge (m^3/sec)

f = Lacey's silt factor

D_{50} is a parameter which reflects diameter of average grain size. The field investigations revealed D_{50} to be 0.003 mm; which is a clay particle and it will not behave as a granular material. Also, it is our engineering judgement that such a fine particle should not be used for calculating "f" value. In earlier studies of year 2013 and 2020 D_{50} value was used as 0.032 mm and 0.030 mm respectively. For the present study (YBRT), we have used D_{50} value to be 0.030 m; from which "f" value computes as 0.96. **In detail design stage, fresh geotechnical investigations will be carried out, and scour value will be updated accordingly**.

For design discharge of 410,000 cusecs, un-factored scour depth "R" is computed as 10.8 m and factored scour depth "XR" is computed as 21.6 m. The flow depth is worked out by HEC-RAS model as 7 m; therefore, un-factored and factored scour depths below average river bed is computed as 3.8 m and 14.6 m respectively.

- By HEC-RAS Model

There are two options for computing scour depth. One option uses Colorado State University (CSU) equation as described in HEC-18 document, and the other option uses Froehlich Equation. Both options were employed and the scour depths were computed as 3.62 m and 3.81 m respectively; which are close enough and are very close to 3.8 m scour depth as computed by the Lacey's method.

For fixing bottom level of piles below the estimated scour level (by structural engineer), it is a routine practice to consider the factored scour depth and subtract it from the HFL. The pier parameters are given in **Table 5.3** below, and **Figure 5.8** shows the scour depth below the river bed level. Such parameters will be finalized by structure engineer. Since the provided waterway of the YBRT Bridge is constricted as compared to the upstream approaching river section, there will be contraction scour. The contraction scour computed by HEC-RAS Model is given in table 5-3.

Table 5-3: Pier Parameters

Pier Shape:	Round nose
Pier Width (m):	1.4
Grain Size D_{50} (mm):	0.30
Grain Size D_{95} (mm):	1.7
Contraction Scour (m)	**1.11**
Pier Scour (m)	**3.81**
Combine Scour Depth Ys (m):	**4.91**

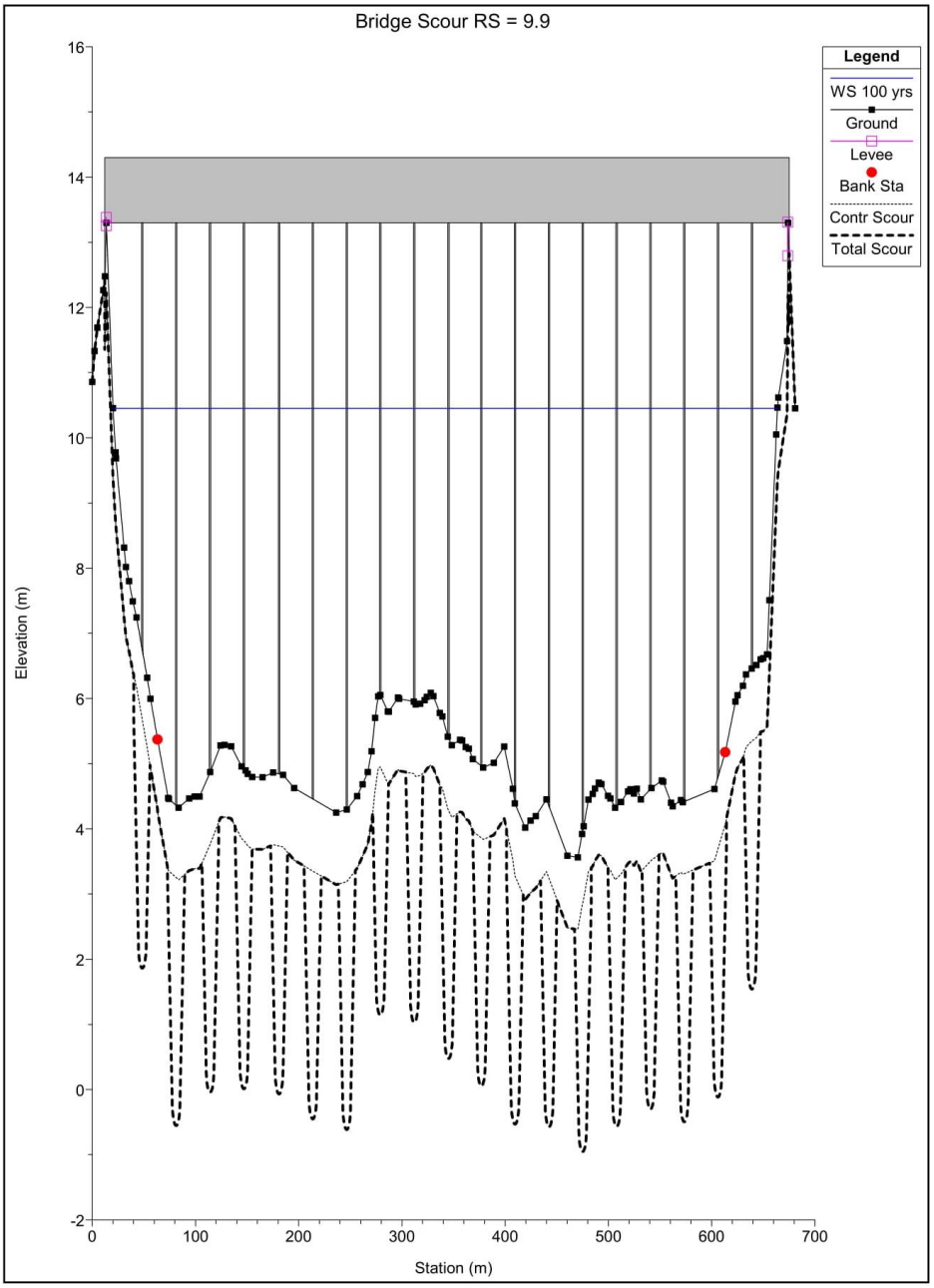


Figure 5-8: Showing Scour Computation by HEC-RAS Model

5.4 HYDRAULIC GEOMETRY OF YBRT BRIDGE

Since the Yellow Line Bridge is parallel to JSB, and very near to it, therefore its spans and pier widths are taken similar to that of JSB. The 20 spans are not of uniform width; however, pier width is fixed as 1.4 m. The provided waterway is 629 m, and the width between abutments is 656 m.

The Lacey's regime width "P" is computed for 409,000 cusecs, and worked out to be 521 m. As the provided water way (629 m) is greater than P, scour computations were made by equation (2).

5.4.1 Hydraulic Design Parameters

Hydraulic design parameters of the proposed bridge are given in **Table 5.4**.

Table 5-4: Hydraulic Parameters of Proposed YBRT Bridge

Discharge	Total Width	No. of Spans	Width of Single Span	Flow Velocity	Highest Flood Level (HFL)	Free Board	Soffit Level	Clear Waterway
(cumecs / cusecs)	(m)	(#)	(m)	(m/s)	(m)	(m)	(m)	(m)
11,580 / 409,000	656	20	31.76 to 33.85	3.53	10.45	2.0	12.45	629

5.4.2 Freeboard

The provision of freeboard depends upon many factors; including the expected amount of debris, the geometry of the channel and floodplain, etc. As per the guidelines of the Federal Flood Commission, 2 m freeboard has been proposed.

ANNEXURE A

Topographic Survey of the Study Area

ANNEXURE A

TOPOGRAPHIC SURVEY OF THE STUDY AREA

A.1 LOCATION & EXTENTS OF THE PROJECT SITE

Survey team carried out the cross sectional and topographical survey as required for the proposed interventions (Korangi Road Bridge). Survey has been carried out in the months of July & August, 2020 in a reach starting from about 800 meters U/S of EBM causeway (Falcon Complex Area) and extending up to downstream of NIP/ PARCO Elevated Oil Pipeline near sea (Reach upstream EBM Causeway area - upstream & downstream of JSB - Korangi Causeway area - downstream of National Industrial Park (NIP)/ PARCO Pipeline). Total length of the study reach is about 6.6 km.

A.2 SCOPE OF SURVEY WORK

Scope of survey work carried out (July & August 2020) mainly included the following;

- Reconnaissance visit of the project area.
- Establishment of survey Bench Marks (BM) in the area.
- Carry out topographic survey work from EBM Causeway to NIP (near sea).
- Preparation of inventory of existing structures.
- Processing of the observed data.
- Preparation of topographic survey map of project area.

The above-mentioned scope of the work has been completed by using the following methodology.

A.3 WORK PLAN AND SITE RECONNAISSANCE VISIT

A comprehensive work plan was established and executed in the field by qualified survey team. Site reconnaissance survey of the study area was carried out to assess the field conditions and general topography to finalize the survey activities/ plan.

A.4 ESTABLISHMENT OF SURVEY BENCH MARK

Establishment of local control points is very important for carrying out surveying and mapping of the area for any engineering project. New technology Global Navigation Satellite System (GNSS) makes it more efficient and effective to establish a primary control bench mark. Often National Geodetic Survey (NGS) vertical control is not readily available within the project area, thus the new procedures allow for establishing a vertical height easily, efficiently, and economically using GNSS.

A project control point was selected and vertical data derived from GNSS observation was used / processed through Online Positioning User Service (OPUS) as a primary control bench mark. The values obtained in World Geographic System (WGS) were transferred to local or Universal Transverse Mercator (UTM) Systems. This BM was used as a reference for further establishment of horizontal and vertical control network for the study area.

The coordinates and location of established control points are presented in Table 3.1 and Table 3.2 in WGS-84 and UTM coordinate system, respectively and shown in Figure 3.1.

Table A-1.1: List of Control Points Coordinates in World Geographic System-84

Sr. No.	Control Point	Latitude (DMS)	Longitude (DMS)	Elevation (m)
1	P1/ BM 02	24° 49' 28.549" N	67° 5' 11.339" E	9.216
2	P1/ BM 04	24° 49' 30.523" N	67° 5' 10.432" E	9.012
3	P1/CP01	24° 49' 35.114" N	67° 5' 12.971" E	11.304
4	P1/CP02	24° 49' 26.292" N	67° 5' 29.806" E	6.123
5	P1/CP03	24° 49' 15.604" N	67° 6' 2.461" E	10.620
6	P1/CP04	24° 48' 52.947" N	67° 6' 43.882" E	5.996
7	P1/CP05	24° 48' 45.311" N	67° 6' 57.809" E	6.652
8	P1/CP06	24° 48' 25.770" N	67° 6' 9.382" E	8.787
9	P4/ BM 01	24° 51' 3.698" N	67° 5' 40.279" E	8.667
10	P4/CP01	24° 51' 3.351" N	67° 5' 40.158" E	8.818
11	P4/CP02	24° 50' 0.666" N	67° 5' 33.083" E	12.733

Table A-1.2: List of Control Points Coordinates in Universal Transverse Mercator – 42N

Sr. No.	Control Point	Easting (m)	Northing (m)	Elevation (m)
1	P1/ BM 02	306610.908	2746881.995	9.216
2	P1/ BM 04	306586.277	2746943.095	9.012
3	P1/CP01	306659.546	2747083.353	11.304
4	P1/CP02	307128.469	2746805.285	6.123
5	P1/CP03	308040.860	2746463.647	10.620
6	P1/CP04	309194.364	2745750.390	5.996

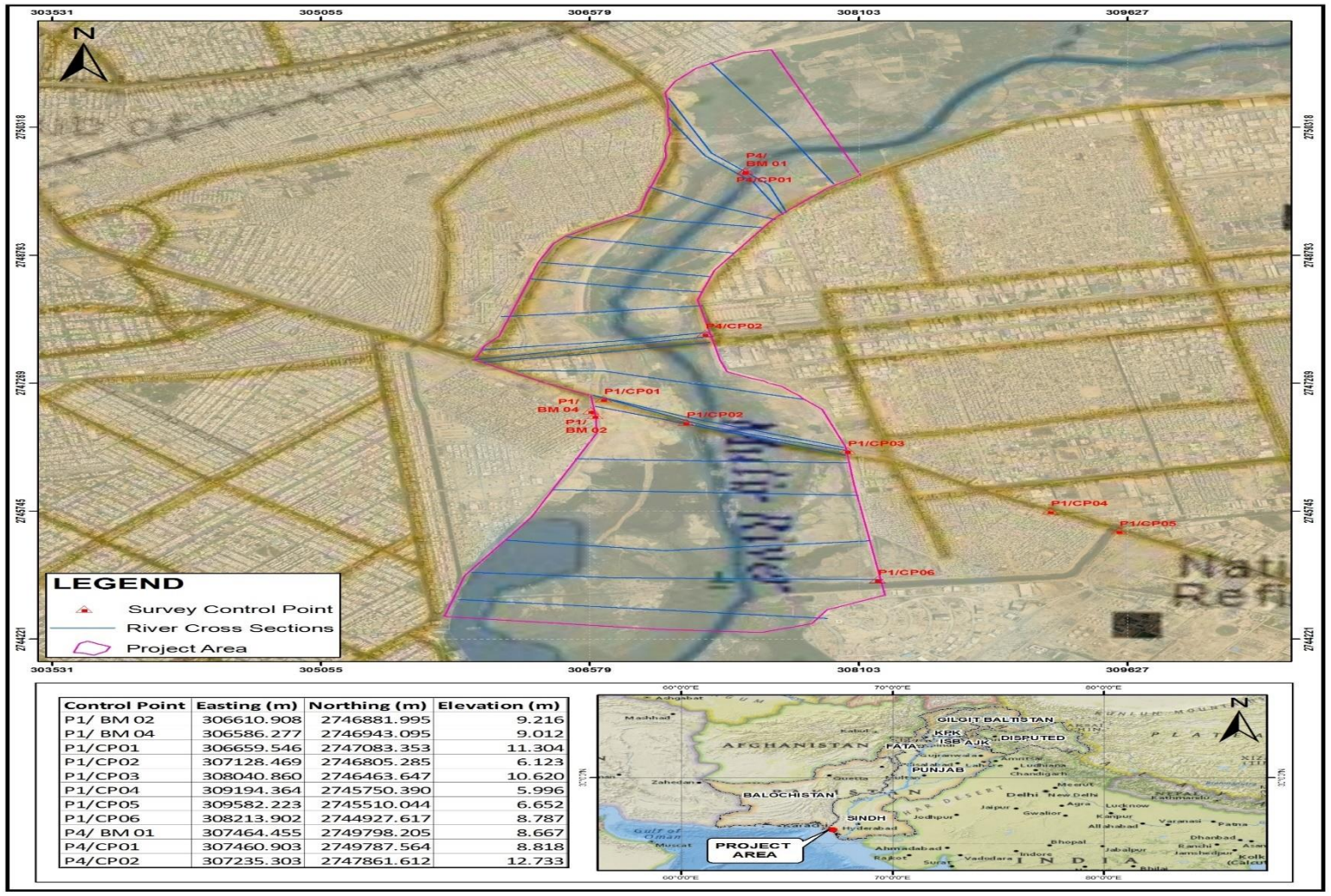
7	P1/CP05	309582.223	2745510.044	6.652
8	P1/CP06	308213.902	2744927.617	8.787
9	P4/ BM 01	307464.455	2749798.205	8.667
10	P4/CP01	307460.903	2749787.564	8.818
11	P4/CP02	307235.303	2747861.612	12.733

In addition to the above topographic survey (conducted from EBM Causeway to NIP) for hydrology and hydraulic study of Malir River, another topographic comprehensive survey of Main BRT Yellow Line Corridor was also conducted in 2021 and some of the above-mentioned control points were also referred/read in order to compare both the surveys. These Control Points can be correlate with the Main BRT Yellow Line Corridor survey (2021) wit with following values in Table A-1.3

Table A-1.3: Comparison of Survey Control Points

Point Name	BRT YL Main Corridor Survey (2021)			Hydrology & Hydraulic Study Survey		
	Easting (m)	Northing (m)	Elevation (m)	Easting (m)	Northing (m)	Elevation (m)
P1/CP03	308040.359	2746463.319	7.497	308040.860	2746463.647	10.620
P1/CP01	306659.082	2747082.921	8.148	306659.546	2747083.353	11.304
P4/CP-02	307234.979	2747861.341	9.680	307235.303	2747861.612	12.733
P1/CP02	307127.829	2746804.869	2.989	307128.469	2746805.285	6.123

While conducting the topographic survey for the requisite hydraulic study, the Contractor must correlate the Survey Datum/Vertical Control with the Chart Datum of Port Qasim or KPT (with conservative approach). Further, the top and invert level of all drains disposing storm and/or sewer in Malir River must also be recorded to consider back watering effect during flooding.



Control Point	Easting (m)	Northing (m)	Elevation (m)
P1/ BM 02	306610.908	2746881.995	9.216
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P1/CP02	307128.469	2746805.285	6.123
P1/CP03	308040.860	2746463.647	10.620
P1/CP04	309194.364	2745750.390	5.996
P1/CP05	309582.223	2745510.044	6.652
P1/CP06	308213.902	2744927.617	8.787
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P4/CP01	307460.903	2749787.564	8.818
P4/CP02	307235.303	2747861.612	12.733

Figure A-1: Location Map of Established Survey Bench Marks

A.5 ELECTION OF CONTROL POINTS LOCATION

Selection of location for control points (Established Bench Marks) were based on three elements i.e., stability for the soil conditions encountered for each point set, safety of the established point and ample clear view to the sky, which are crucial for GNSS observations. In order to mitigate errors and increase accuracy, the control network was planned and designed to form triangles wherever possible.

A.6 ESTABLISHMENT OF HORIZONTAL AND VERTICAL CONTROL NETWORKS

Horizontal and vertical project control survey was established for the project. Whenever feasible, the horizontal and vertical control is based on high-precision GNSS observations. In order to achieve maximum possible accuracy and minimal spatial variations in both horizontal and vertical planes, control network was established by using state of the art "GNSS" equipment encompassing the entire project area. For base line computation, three (3) GNSS instruments were used simultaneously. To receive the signals from satellite, the receiver should have minimum obstructions like building, trees, power lines etc, around it. The signal can be weakening due to unfavourable weather conditions like rainfall, clouds and vehicle noise. The observations have to be repeated till satisfactory readings/data. For all time observations, at least four (4) satellites should be available with Geometric Dilution of Precision/Position Dilution of Precision (GDOP/PDOP) value of less than five (5). The availability of satellites and GDOP value can be known in advance with the help of computer program for given time, date and point of observations. Each instrument is set to work at least 30 minutes for simultaneous observations. Out of three (3) receivers, one acted as reference (for which coordinates of the observing point are known) and the other two (2) as rovers (coordinates to be computed). The observed point coordinates served as reference for further observing points to make a triangle or large polygon. Control Points (CPs) have been engraved at the permanent structures.

The accuracy of the survey control points in static mode is as follows:

Horizontal ……... ± 3 mm +1 ppm RMS
Vertical……..……... ± 5 mm +1 ppm RMS

A.7 INSTRUMENTS USED

The Leica Viva GS 10, GS 15 and Trimble R2, R9 were used to establish the control points. Also, these systems with one base and receivers (rovers) were used to collect the survey data in Real Time Kinematic (RTK) mode.

The base station was placed on the known control point and the rover was used for collecting the survey points. The accuracy of the GNSS equipment in RTK mode is as follows:

Horizontal …….. ± 10 mm +1 ppm RMS
Vertical…….. ± 20 mm + 1 ppm RMS

A.8 MEASUREMENT UNITS

The linear measurement units used in survey and mapping work are metric and the angular measurement are in degrees, minutes and second of arc.

A.9 FIELD DATA PROCESSING

The data observed was downloaded to laptop which was available with survey team at the survey site. The data was processed and checked at the site for quality and gaps, if any. The GPS baselines were processed using Leica Geo Office (LGO) and Trimble Business Centre (TBC) software. The default acceptance criteria for baselines were used in LGO & TBC. Any baseline not fulfilling the acceptance criteria was repeated. As the GNSS reading is based upon the WGS-84, the data was converted into UTM Zone 42.

A.10 SOFTWARE USED

All the observed data was processed using LGO, TBC and ArcGIS software, which are widely used for field data processing. AutoCAD and Eagle Point software were used for preparation of the topographic survey layouts from the field survey data.

A.11 DATA PROCESSING AND PRODUCTION OF DRAWINGS

The observed data was digitized using AutoCAD software in the form of points, lines and polygons. The digitization of features was done in different AutoCAD layers. The feature layers have unique style and symbols so that these can be well distinguished from other features. Finally, the layouts were prepared on appropriate scale for further study and analysis. All features like settlements, roads, bunds, etc., have been observed crossing the desired cross-sectional lines.

One cross section get from July & August, 2020 survey is shown in **Figure A-2**.

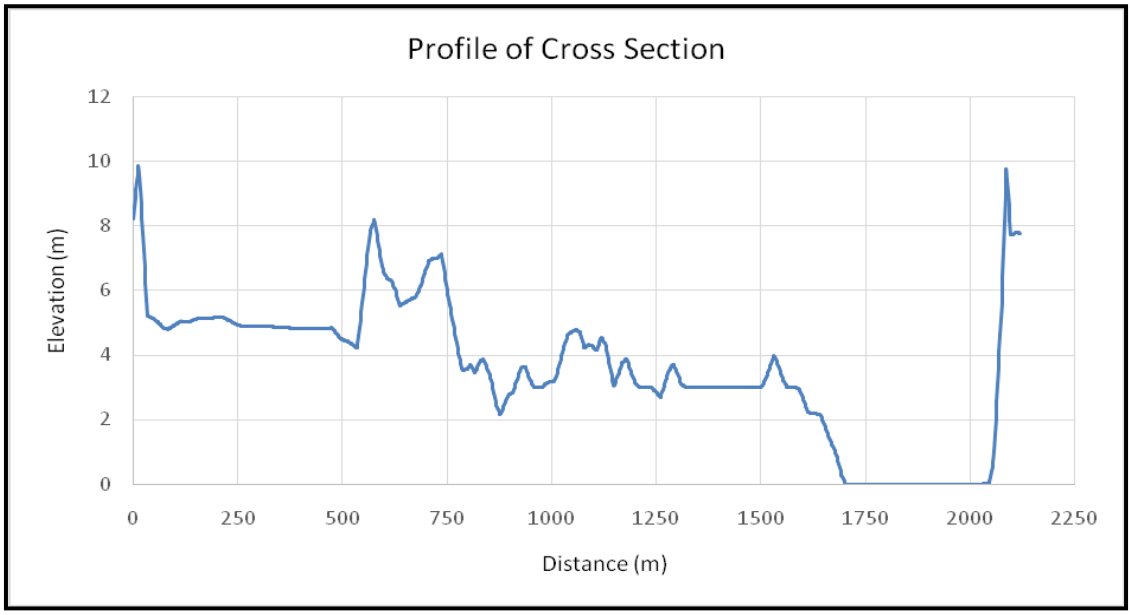
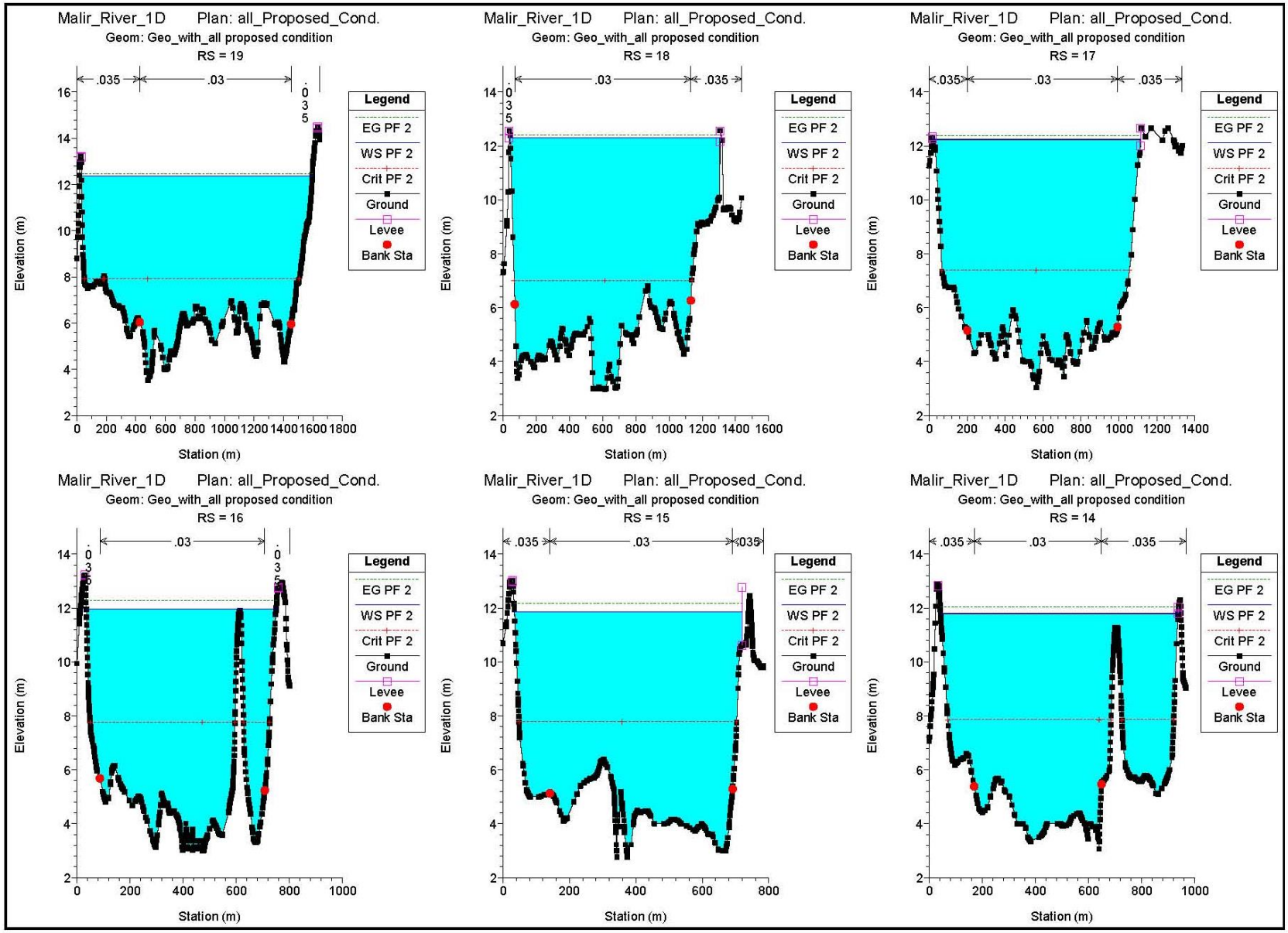


Figure A-2: Surveyed Cross-Section from NESPAK Survey in 20

ANNEXURE B

Hydraulic Model Cross Sections of the Project Area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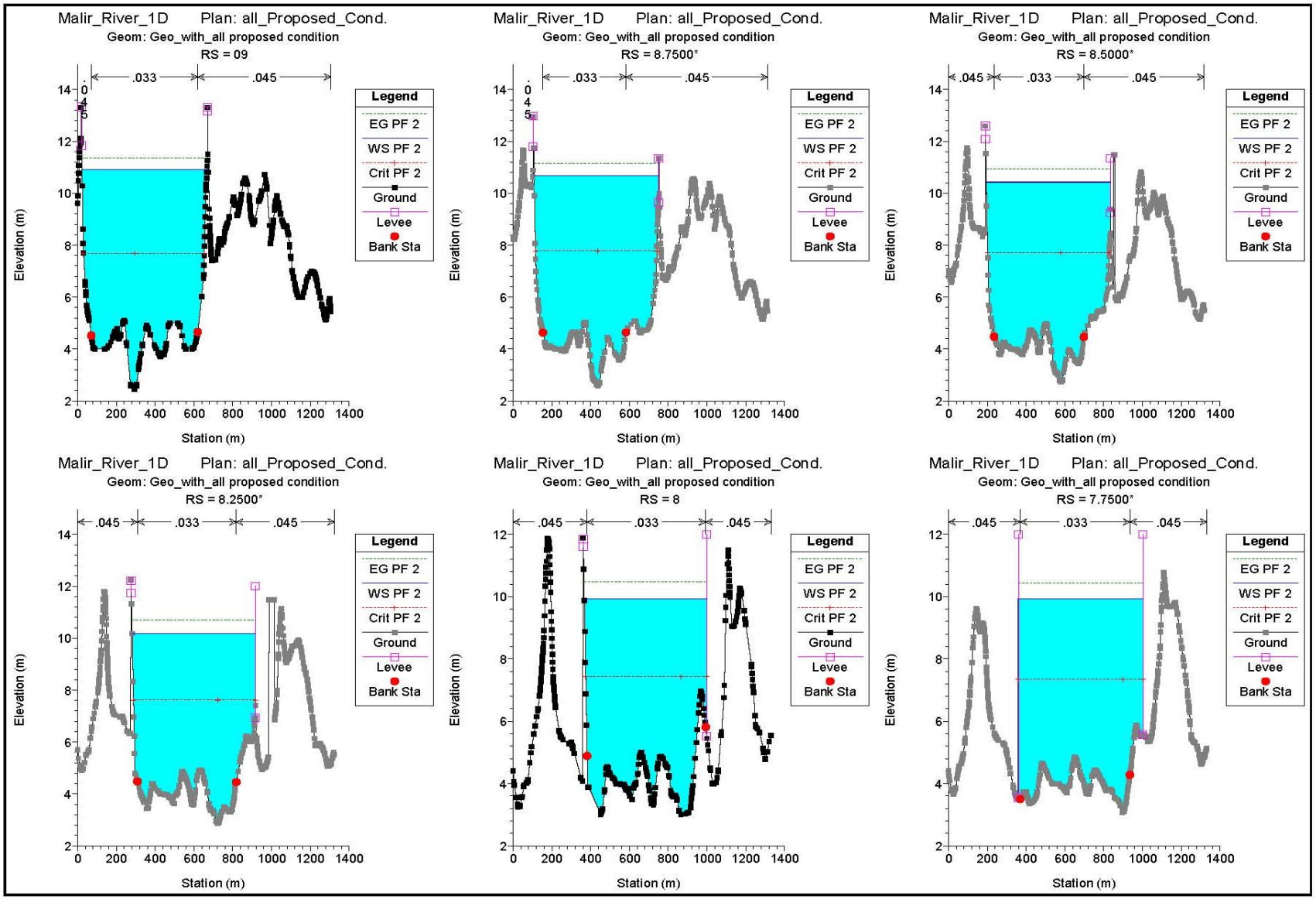
Station (m)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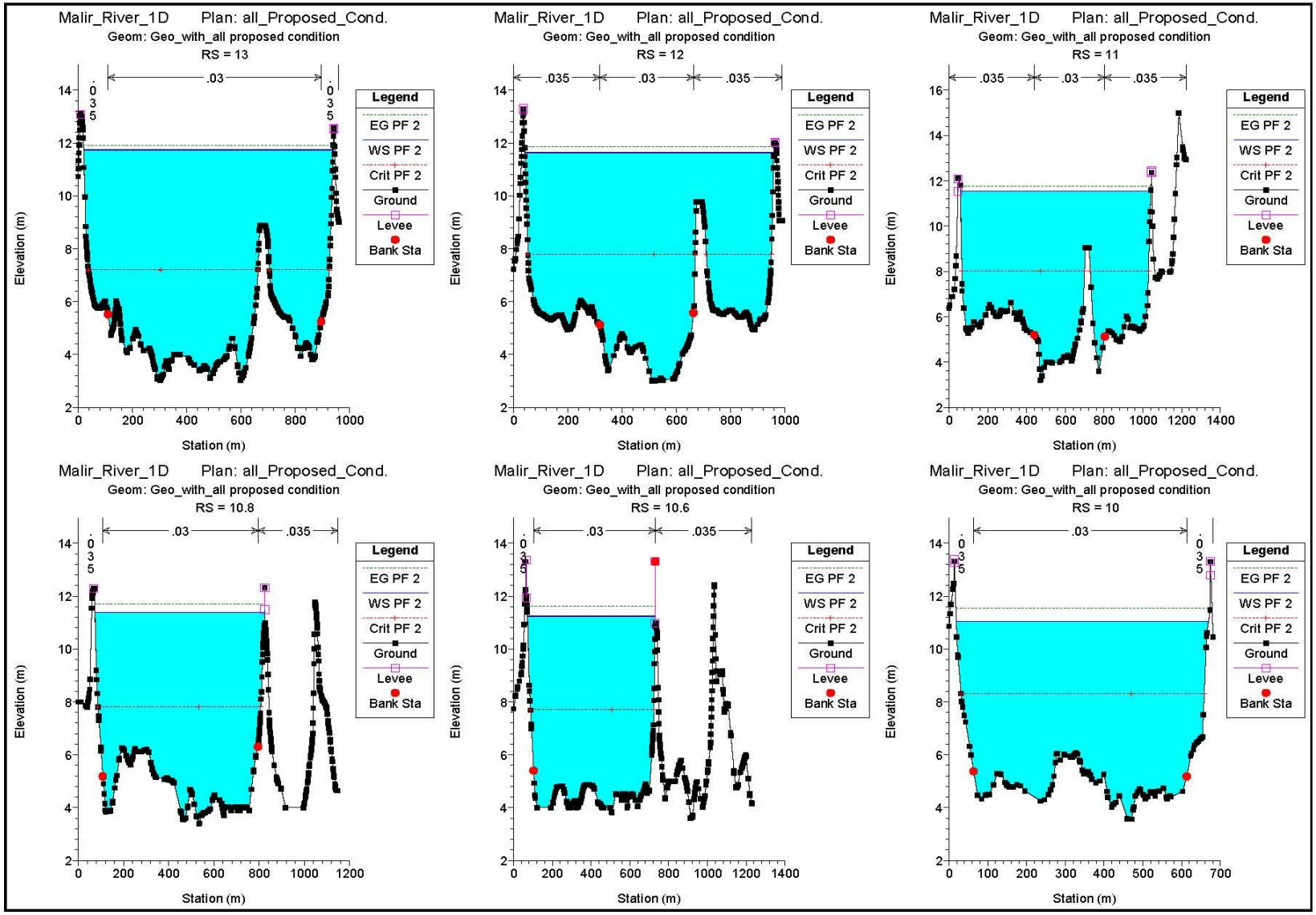
Station (m)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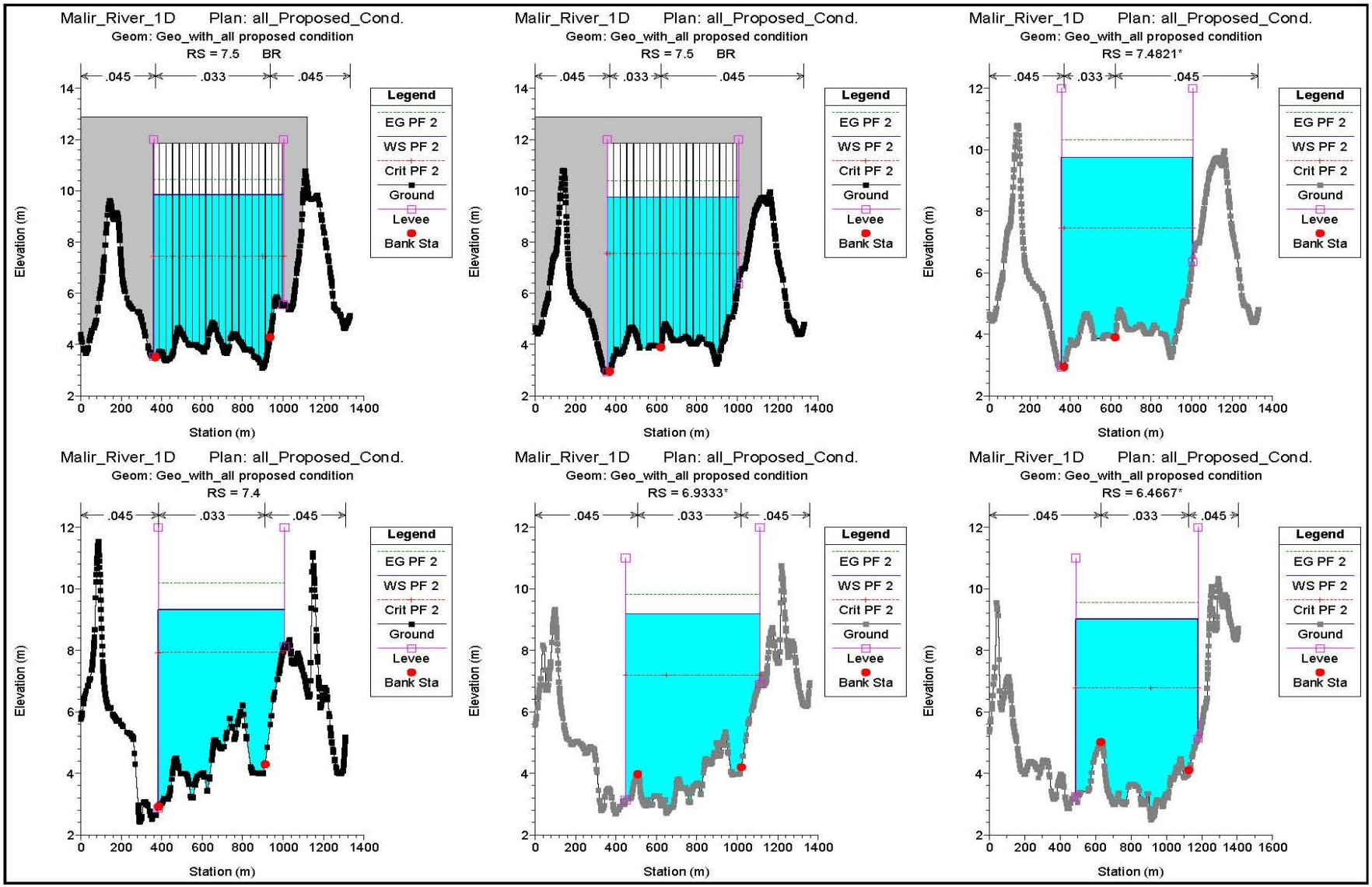
Station (m)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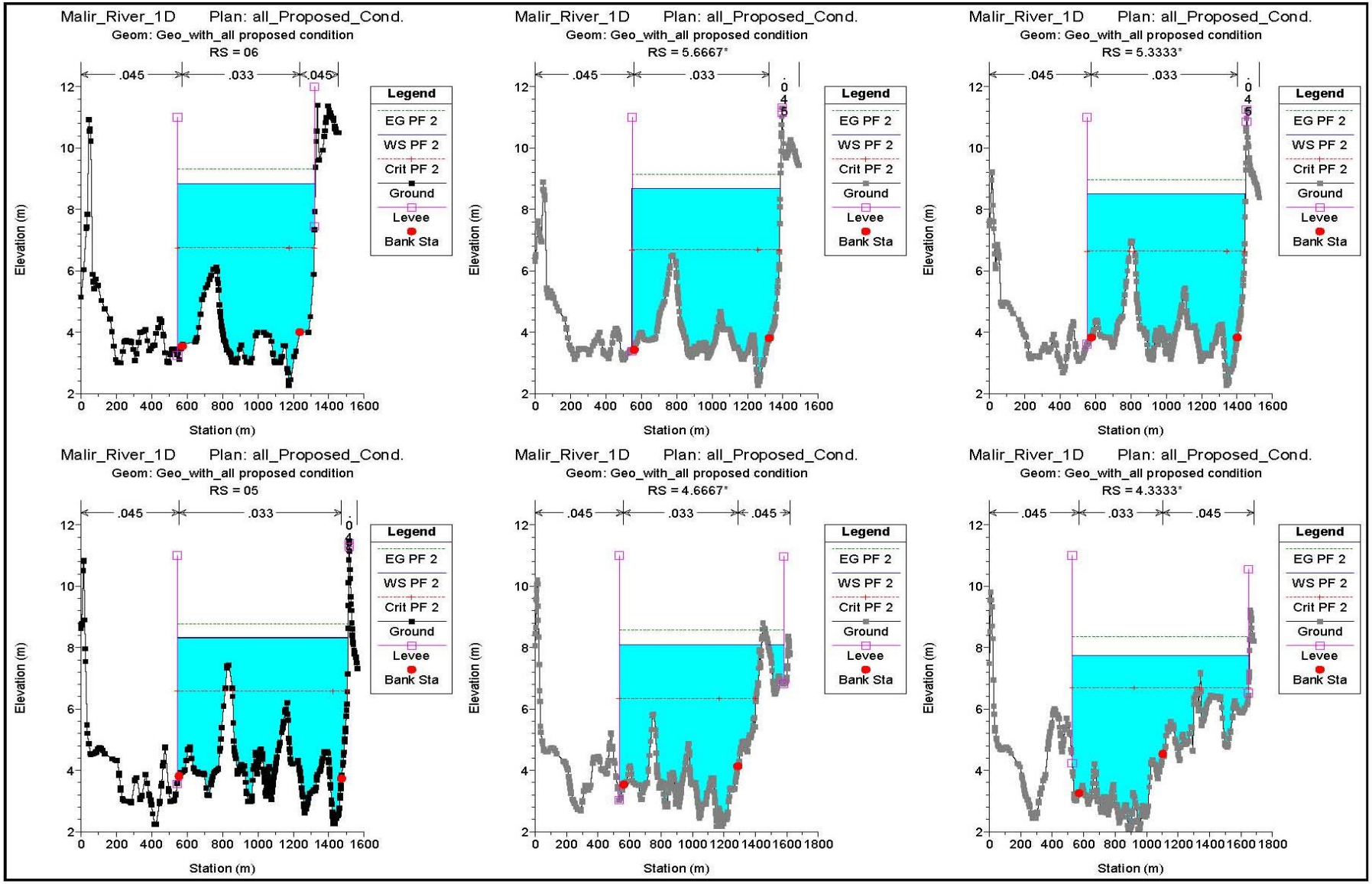
Station (m)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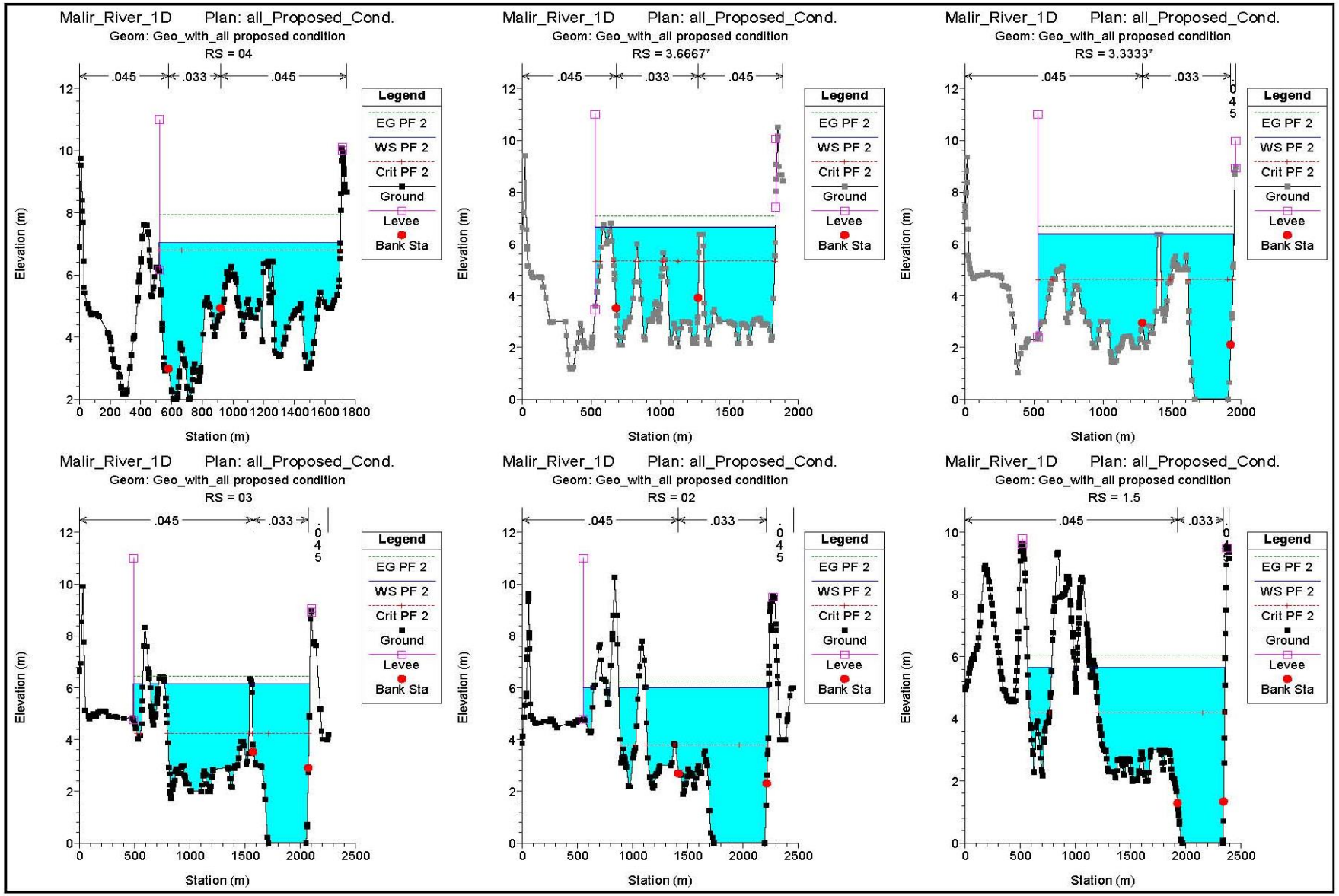
Station (m)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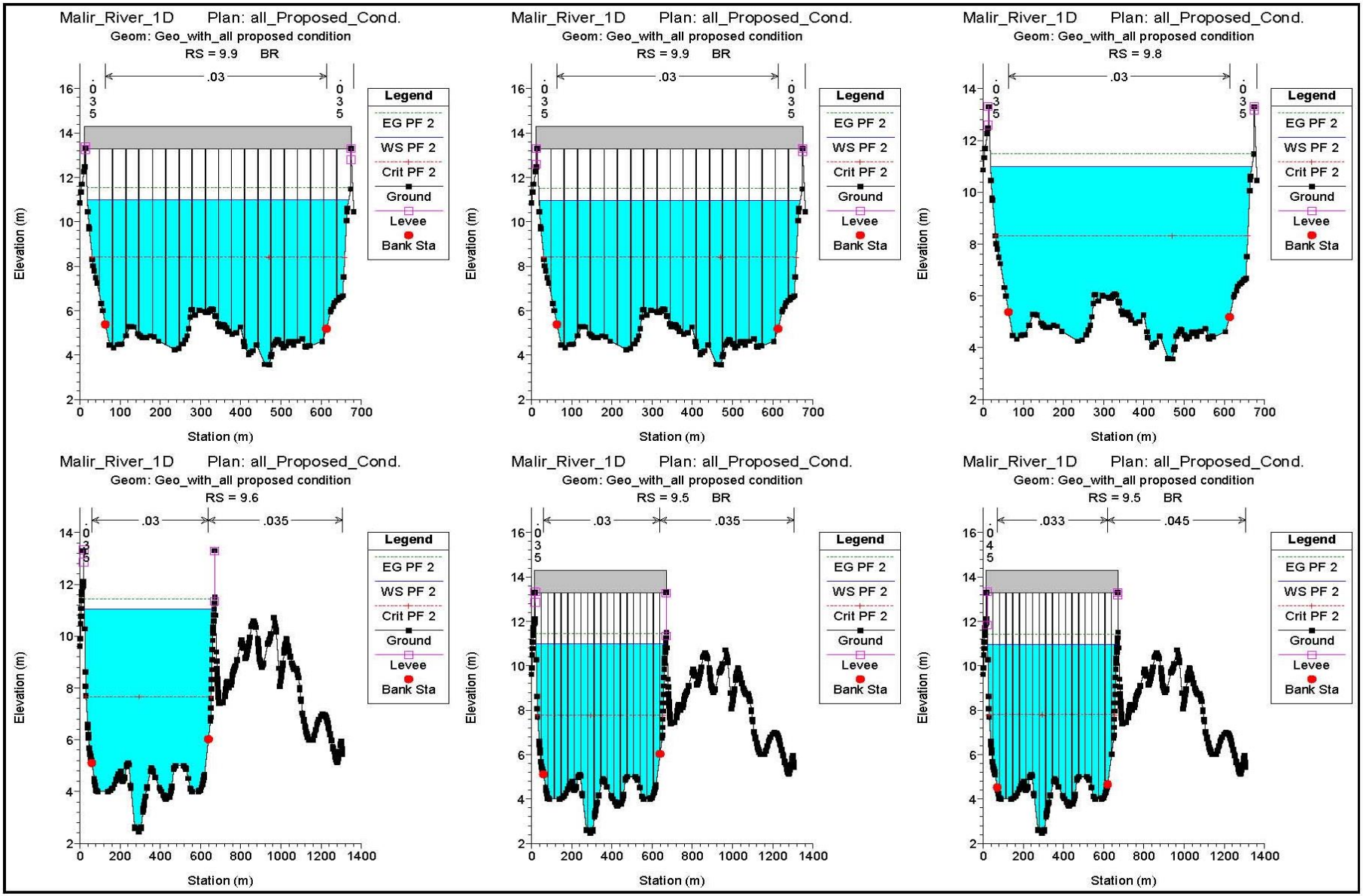
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Levee
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Station (m)
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Levee
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Station (m)
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Bank Sta
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Bank Sta
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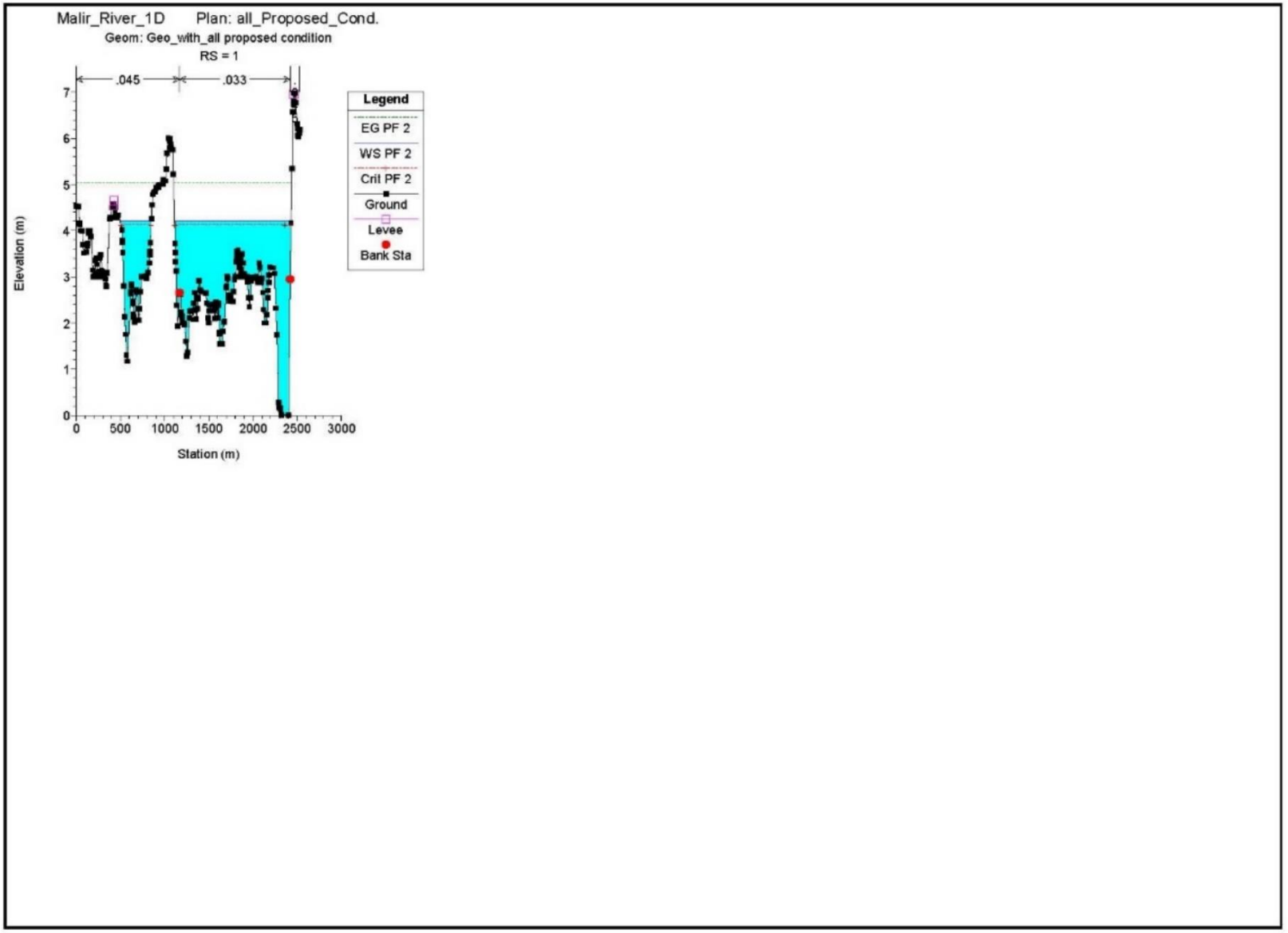
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Levee
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Station (m)
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1000
1500
2000
2500
3000
1
2
3
4
5
6
7

Volume 5C - Environmental and Social Management Plan

Request For Proposal Documents
Works (Design and Build)

Main Contents

VOLUME (1): **Instructions to Proposers (ITP) &**
Proposal Data Sheet (PDS), Proposal Forms / Schedules,
Conditions of Contract, Contract Forms / Schedules

Part 1 - Request for Proposal Procedures
Section I Instructions to Proposers (ITP)
Section II Proposal Data Sheet (PDS)
Section III Evaluation and Qualification Criteria
Section IV Proposal Forms
Section V Eligible Countries
Section VI Fraud and Corruption

Part 2 - Employer's Requirements
Section VII Employer's Requirements

Part 3 - Conditions of Contract and Contract Forms
Section VIII General Conditions (GC)
Section IX Particular Conditions (PC)
Section X Contract Forms

VOLUME (2):

Part (A) Employer's Requirements
1) Introduction
2) General Overview of the Project
3) Design Intent
4) Design Responsibility
5) Interface Management
6) Design Stages and Deliverables
7) Basis of Design

Part (B) Specifications (1 of 2)
Division 01 - General Requirements

Part (B) Specifications (2 of 2)
Division 02 - Site Construction
Division 03 - Concrete
Division 07 - Thermal and Moisture Protection
Division 26 - Electrical
Division 31 - Earthwork
Division 32 - Exterior Improvements
Division 33 - Utilities
Division 34 - Transportation

VOLUME (3): Basis of Pricing & Pricing Schedules

Basis of Pricing

Pricing Preambles
1 Design & Special Works
2 Bridge Works
3 Roadworks
4 Electrical Works
5 Utilities

Pricing Schedules

Summary
1 General and Particular Conditions of Contract
2 General Requirements
3 Design & Special Works
4 Bridge Works
5 Roadworks
6 Electrical Works
7 Utilities

VOLUME (4): Drawings

01- Roads
02- Bridge
04- Utilities

VOLUME (5): Technical Documents "For Information":

5A - Geotechnical Investigation
5B - Hydrology and Hydraulics Study Report
5C - Environmental and Social Management Plan
5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Environmental and Social Management Plan (ESMP) is an instrument that details the measures to be taken during the implementation and operation of a project to eliminate or offset adverse environmental and social impacts, or to reduce them to acceptable levels; and the actions needed to implement these measures. ESMP consists of the set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts. The main objectives of ESMP are to:

- Provide details of the project impacts along with the proposed mitigation measures and the corresponding implementation activities;
- Define the role and responsibilities of the Project Proponent, Contractor, Supervisory Consultants and other role players and effectively communicate environmental issues among them;
- Define a monitoring mechanism, reporting frequency and identify monitoring parameters to ensure that all the mitigation measures are completely and effectively implemented;
- Identify the resources required to implement the ESMP and outline the corresponding financing arrangements; and
- Ensure that the project will adopt COVID 19 best international standard operating procedures (SOPs) during the construction and operational phases.

1.1 REGULATORY REQUIREMENTS

Following is the regulatory requirements including national and international regulations to be considered in the project:

National Laws, Regulations and Policies
National Conservation Strategy, 1992
National Environmental Policy (NEP), 2005
National Forest Policy, 2001
Pakistan Labour Policy, 2010
National Climate Change Policy, 2012
National Water Policy 2018
National Sustainable Development Strategy, 2012
National Action Plan for Covid-19 Pakistan
Pakistan Penal Code, 1860
Occupational Health
Building Code of Pakistan
Antiquities Act 1975
International Labor Organization (ILO)
Employment of Child Act, 1991
Guidelines for Environmental Assessment, Pakistan EPA
Solid Waste Management Guidelines (2005)
National Gender Policy Framework

Provincial Laws, Regulations and Policies

Sindh Strategy for Sustainable Development, 2007
Sindh Drinking Water Policy, 2017
Sindh Environmental Protection Act, 2014
Sindh Environmental Protection Agency (Environmental Assessment) Regulations, 2021
Sindh Environmental Quality Standards (SEQS), 2016
Sindh Cultural Heritage Act, 1994
Sindh Wildlife Protection (Amendment) Act, 2008
Land Acquisition Act, 1894 (Sindh Amendment Act, 2009)
Sindh Public Property Act, 2010
Forest Act 1927 (Amended as Sindh Forest Act, 2012)
Sindh Solid Waste Management Board (SSWMB) Act, 2014
Sindh Factories Act 2015
Sindh Fisheries (Amendment) Act 2011
The Sindh Local Government Act 2013 and Sindh Local Government (Amendment) Act, 2019
The Sindh Transparency and Right to Information Act, 2016
The Protection against Harassment of Women at the Workplace (Amendment) Act, 2022
Transgender Persons (Protection of Rights) Act, 2018
Employment of Children Act, 1991
Labor Laws as part of Constitution of Pakistan 1973
Hazardous Substances Rules, 2014
The Sindh Minimum Wages Act, 2015
The Sindh Occupational Safety and Health Act, (2017)
Sexual Violence Response Framework, Government of Sindh 2020- 2024

International Convention, Protocols and Obligations

Convention on Wetlands (RAMSAR Convention), 1971
Bonn Convention-The Convention on Conservation of Migratory Species of Wild Animals, 1979
Convention on International Trade of Endangered Species of Flora and Fauna (Cites)-1979
The Basel Convention, 1989
The Rio Declaration, 1992
United Nation Framework Convention on Climate Change (UNFCCC), 1992
Sustainable Development Goals (SDGs) – 2015-2030
Paris Agreement, 2016

Applicability of World Bank Safeguard Policies

OP 4.01 Environmental Assessment
OP 4.04 Natural Habitats
OP 4.12 Involuntary Resettlement
OP 4.36 Forestry
Labor Influx
WB EHS Guidelines
World Bank Group Gender Strategy (2016-2023)

1.2 INCLUSION OF ESMP IN BIDDING/ CONTRACT DOCUMENTS

The ESMP will be included in the bidding/contract documents and their implementation will be a contractual binding for the contractors.

1.3 INSTITUTIONAL ARRANGEMENTS

The proposed organizational structure for the implementation of the ESMP is presented in **Figure 1.1** and roles and responsibilities of key role players are given in **Table 1.1.**

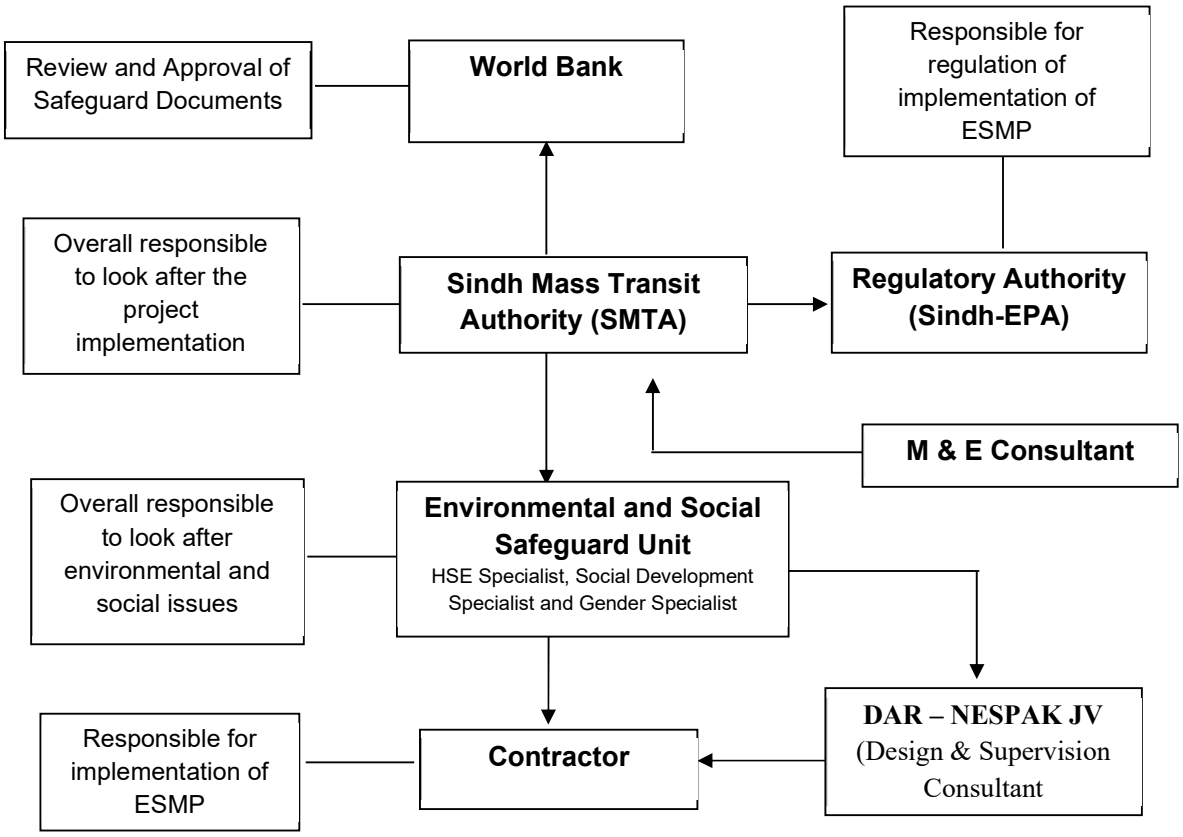

Review and Approval of Safeguard Documents
World Bank
Responsible for regulation of implementation of ESMP
Overall responsible to look after the project implementation
Sindh Mass Transit Authority (SMTA)
Regulatory Authority (Sindh-EPA)
M & E Consultant
Overall responsible to look after environmental and social issues
Environmental and Social Safeguard Unit
HSE Specialist, Social Development Specialist and Gender Specialist
Responsible for implementation of ESMP
Contractor
DAR – NESPAK JV
(Design & Supervision Consultant

Figure 1.1: Institutional Arrangement for Implementation of ESMP

The SMTA will monitor and coordinate all project implementation activities. The Project Director, will be responsible for all aspects of project implementation including financial management, procurement, recruitment of staff, consultants and contractors, and overseeing the implementation of ESMP.

Environmental and Social Safeguard Unit (ESSU)- SMTA

Environmental and Social Safeguard Unit (ESSU) will be established under SMTA, consisting of the following staff:

- Environment, Health and Safety Specialist
- Social Development Specialist

- Gender Specialist

Overall responsibilities include:

- To ensure implementation of mitigation measures proposed in EMP during the construction and operational phase of the Project;
- To organize monitoring of ambient air quality, water and noise. In case, the noise and emission levels exceed the acceptable levels; a penalty or ban must be enforced;
- To develop operational guidelines and implementation schedule;
- Receiving complaints from nearby community and assisting the local authority including liaison with SEPA;
- Ensuring availability of committed human resources and sufficient budget for successful implementation of EMP;
- To ensure that the proposed project is implemented in an environment friendly manner,
- Maintaining interface with the other lined departments/stakeholders; and
- Reporting to the SEPA on status of EMP implementation.

Design & Supervision Consultant (DAR – NESPAK JV)
Overall responsibilities of Construction Supervision Consultant include:

- Supervising, facilitating and coordinating implementation of environmental and social plans including ESMP;
- Ensuring that contractors follow Sindh EPA regulations, World Bank Safeguard Guidelines and Policies, and other requirements mentioned in the ESMP;
- Identifying any issues of non-compliance and maintain a record;
- Suggesting mechanisms to link contractor performance in relation to the ESMP to the timing of financial payments, incentives or penalties;
- Interacting with stakeholders for their concerns about the construction activities.
- Assisting Project Director in addressing and resolving environment-related complaints and grievances;
- Identifying and preparing environmental training materials and conducting environmental trainings; and
- Reviewing ESMP and revising it if required.

Contractors

Contractor(s) are also required to appoint the following staff for the implementation of ESMP in the field, particularly the mitigation measures.

- Environmental, Health and Safety Expert
- Social Development Expert and
- Gender Expert

The contractor will develop site specific management Plans addressing towards health, safety and environment and social issues including gender and get them approved by the SMTA. The contractor will also be responsible for communicating with and training its staff in the environmental/social and gender issues before the commencement of the construction works. The construction contract will have appropriate clauses to bind the contractor for the above obligations.

Monitoring and Evaluation Consultant (M & EC)
MEC will be recruited by SMTA to carry out independent monitoring of implementation of ESMP. The MEC will have environmental, social and gender experts and shall carryout third party monitoring of the project. MEC will also carry out regular observation of implementation of ESMP carried out by the contractor.

1.4 ENVIRONMENTAL MANAGEMENT

Mitigation Plans

Mitigation and management plans shall be prepared on the basis of the detailed impact assessment and recommended measures. These plans shall be project-specific and shall be prepared by contractor prior to the commencement of construction activities. These plans will be reviewed and approved by SMTA. A brief description of each of these plans is provided below:

Erosion and Drainage Control Plan will be prepared by the contractor on the basis of the mitigation measures given in ESMP. The Plan will be submitted to SMTA for review and approval before contractor mobilization.

Pollution Prevention Plan will be prepared and implemented by the Contractor on the basis of WBG EHS Guidelines (2007), as well as the mitigation plans given in ESMP. The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

Waste Disposal and Effluent Management Plan will be prepared and implemented by the Contractor on the basis of WBG EHS Guidelines (2007), as well as the mitigation plans given in ESMP. The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

Traffic Management Plan will be prepared by the Contractor on the basis of the mitigation plans given in ESMP, after discussion with SMTA and authorities responsible for roads and traffic. The Plan will be submitted to the SMTA for their review and approval before contractor mobilization.

Borrow Area Management and Restoration Plan for management and restoration of borrow areas will be prepared by the Contractor on the basis of requirements described in the mitigation plans. This Plan will aim at minimizing the environmental and social impacts during borrowing activities and restoring as much as possible the original natural situation of these sites by various measures (refill, leveling or smoothening). Restoration methodologies will be included in the Plan. The Plan will be approved by the SMTA.

Drinking Water Supply and Sanitation Plan: Separate water supply and sanitation provisions will be needed for the temporary facilities, labor camps and workshops, in order not to cause shortages and/or contamination. The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

Construction Camp Management Plan will be prepared by the Contractor on the basis of the mitigation plans given in ESMP. The Plan will include the camp layout, details of various facilities including supplies, storage, and disposal. The Plan will be submitted to the SMTA for review and approval before camp establishment.

Fuel and Hazardous Substances Management Plan will be prepared by the Contractor on the basis of mitigation plans given in ESMP and in accordance with the standard operating procedures, relevant guidelines, and where applicable, material safety data sheets. The Plan will include the procedures for handling oils and chemical spills. The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

Emergency Preparedness Plan will be prepared by the Contractor after assessing potential risks and hazards that could be encountered during construction of road. The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

Communication Plan will be prepared by the contractor to demonstrate how they will communicate with local community leaders, provide details regarding employment opportunities, and traffic management throughout the construction period. The contractor's communication plan should define a process for receiving, recording and responding to complaints and also monitoring of the success of any responsive action taken to prevent the escalation of any conflicts.

Camp Site Restoration and Rehabilitation Plan will be prepared by the contractor. The main areas to be considered for site restoration & rehabilitation include the construction area, campsite area, temporary tracks; land used for vehicles, material stores etc. These areas should be restored to their original condition with the maximum possible effort. The restoration work comprises the removal of temporary construction works and removal of any fences installed and levelling of the area (wherever required) etc. The following procedures will be adopted for the restoration of the project site and nearby sites:

- All temporary construction built for the site development will be removed;
- Site for construction camps will be restored to its original (pre-construction) condition as much as possible;
- All the toxic and hazardous chemicals/materials will be completely removed from the site. Efforts will be made to completely remove the oils and chemical spills which occurred during the construction stage;
- Any debris from the construction site will be removed properly from the site and disposed of in an environmentally friendly manner; and
- All fencing and gates will be removed and pits will be backfilled; and
- Whole of the site will be covered with the original soil and plantation will be done, wherever required.

To achieve the above objectives, the Contractor will prepare a Camp Site Restoration & Rehabilitation Plan well before the completion of the construction activities and submit to SMTA through the SC for approval. Finally, after the completion of the restoration process, SMTA through the representatives of the Environmental Management and Monitoring Cell and other community members will inspect the site and give restoration clearance to the Contractor.

Spoil Disposal Areas Management and Restoration Plan will be prepared by the Contractor. The Plan will describe the procedures for spoil management, transportation and disposal at the selected site(s). The Plan will also describe the procedures for systematically disposing the spoil at the disposal site. This Plan would aim at minimizing the environmental and social impacts during disposal activities and restoring as much as possible the original natural situation of these sites by various measures (landscaping, leveling or smoothening). The Plan will include measures to avoid land/soil erosion and

landslides. Restoration methodologies will be included in the Plan. The Plan would be approved by the SC and a landscape architect assigned by SMTA.

Occupational Health and Safety Plan will be prepared and implemented by the Contractor on the basis of the WBG EHS Guidelines (2007) and other relevant standards. The plan also includes the transportation/movement, storage and usage of explosive materials in compliance with Explosive Act, 1884, Explosive Rules, 2010 and BS5607 (British Standards). The Plan will be submitted to the SMTA for review and approval before contractor mobilization.

1.5 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The impacts, mitigation measures, monitoring indicators, frequency and responsibility has been documented in ESMP and given in **Table 1.1.**

Table 1.1: Environmental and Social Management Plan

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
POTENTIAL ENVIRONMENTAL IMPACTS				
Pre-Construction / Design Phase				
01	**Drainage** Improper drainage may cause deterioration of structure and poor travelling conditions.	▪ Ensure that the existing drainage system is clean and free from debris and can withstand the storm water generated during rainfall and relocation/ new drains shall be designed considering rainfall intensity, land use pattern, topography of the project and catchment of the adjacent area, and type of structures within the project area.	Design Consultant	SMTA
02	**Topography** The topography of the project area will change due to the construction of project.	▪ Visual changes to the topography will be of permanent but slightly adverse in nature and need no mitigation measures except that the project design should consider aesthetic concerns.	Design Consultant	SMTA
03	**Seismic Hazard** The Project Area is located in Seismic Zone 2B, where 2B (upper limit of moderate damage) represents peak horizontal ground acceleration from 0.16 to 0.24 g. In this Zone, designing of various types of structures should be done on the basis of Peak Ground Acceleration (PGA). A low to moderate intensity earthquake impacting the project site can adversely impact the development.	▪ The proposed project and the associated structures should be designed and constructed as per Seismic Building Code of Pakistan 2007 (SBC-07) to comply with minimum requirements for seismic safety of structures.	Design Consultant	SMTA
04	**Flora** During the pre-construction phase, activities such as installation of construction camps, construction of temporary roads and mobility of construction staff may damage	▪ The camps, mobility of machinery and construction of any temporary road shall be proper planned and well designed to avoid any loss to local green cover; ▪ It is recommended to establish the construction camps where minimum or no vegetation exists;	Design Consultant	SMTA

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	the local vegetation/trees. As the heavy machinery and camps will be moved and installed, which require significant space due to which available vegetation is expected to be removed. The trees and shrubs, coming within the ROW may be affected including mature and sub-mature tree/plants species will be disturbed during the construction phase of the Project. Trees act as a binding force as their roots are spread in the soil, which helps to keep the soil intact. With the removal of trees, this binding force will be vanished and the soil will be liable to increased erosion.	▪ Similarly, the alternate points for camps are recommended where no loss of vegetation is expected; ▪ The location of construction camp will be selected so, as to have limited environmental effect during construction phase and to reduce the cost and land requirement; ▪ Cutting of trees and disturbance of green patches shall be avoided, as far as possible so, that negative effects on the process of natural regeneration of species are minimized and possible alternate route must be considered for proposed road, in which minimum ecological and environmental losses are expected; ▪ Incorporate technical design measures to minimize removal of trees and loss of green land, if possible such as change in alignment; ▪ Utmost effort shall be made in the design to save as many trees as possible and minimize the loss of vegetation; ▪ A tree plantation program shall be formulated with the recommendations and technical support of concerned authority or Forest Department; ▪ As a principal, ten trees shall be planned as a compensation in place of falling of one tree in consideration of mortality i.e. 1:10; SMTA shall implement the program with the help of Forest Department or concerned authority and with the consultation of concerned consultant ecologist; ▪ The implementing department shall involve the local communities for carrying out plantation, to develop ownership and to educate them; and ▪ The indigenous trees most suited to the tract should be re-planted and reforested.		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
05	**Layout Planning & Design** To ensure safe and efficient functioning of the facility.	▪ All structural, layout and engineering design of the project should be in strict accordance with the applicable national and international byelaws and positive impact of permanent nature.	Contractor	Construction Supervision & Design Consultant (CSDC) & SMTA
06	**Land Acquisition and Resettlement** The proposed project will be developed on Government Land on the existing and available ROW In case of additional land required, the detail of land under the impact and record of ownership status will be prepared by the Revenue Department.	The Land Acquisition Act (LAA) of 1894 is the main law regulating land acquisition for public purpose. This impact can be mitigated by ensuring compliance of Land Acquisition Act, 1894, addressing community grievances on priority basis and timely compensation to affectees. The process of land acquisition and compensation should be followed in a transparent manner to minimize the impacts to provide judicious compensation to the displaced by providing sufficient budget in the project cost. According to Land Acquisition Act 1894, the following points are to be considered while determining compensation for the project affectees: ▪ The market value of land at the date of publication of notification under section 4 sub section (1); ▪ The damage sustained by the person interested, by reason of the taking of any standing crops, or trees which may be on the land at the time of the collector's taking possession thereof; ▪ The damage if any sustained by the person interested at the time of the collector's taking possession of the land by reason of acquisition injuriously affecting his other property, moveable, or immoveable, in any other manner, or his earning; and	Design Consultant	SMTA

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ As a consequence of the acquisition of the land by the collector, the person affected is compelled to change his residence or place of business, the reasonable expenses incidental to such change. Therefore, compensation should be made to the affected people as per Land Acquisition Act, 1894, provincial rules and World Bank Operational Policies, OP 4.12 and market value for the loss of assets. Adequate budget will be provided in the Project cost for this compensation.		
07	**Temporary Acquisition of Land** The Contractors will require temporary land acquisition for: ▪ The development of Contractor camps and facilities i.e. storage, workshops, equipment parking and washing areas; ▪ Aggregate quarries; and ▪ Access roads/tracks for haulage, transportation etc. The approximate area required for the establishment of one Contractor's camp facilities will be 1500m^2 at the different locations. Land utilization for Project activities and subsequent operation of Project may induce temporary as well as permanent changes in the existing land use pattern. Moreover, the contractor will	▪ It is the foremost option to establish the construction camps at the acquired land to eliminate the issues of land leased etc. however, if this option is not feasible than the land for above mentioned facilities should be selected and leased prior to the start of construction phase. ▪ Land for above mentioned facilities will be directly rented from the private landowners by the Contractors. The provisions of the Land Acquisition Act (LAA), 1894 will not be involved as the acquisition of the land will be temporary and will be covered by short-term lease agreements between the landowners and Contractor. Rental terms should be negotiated to the satisfaction of the concerned landowners and the agreement should be in local language to make the process clear. In addition, these project facilities should be located at a minimum distance of 500 meter from the existing settlements, built-up areas, archaeological and cultural monuments (if any) as the case may be. Prior to the commencement of the construction activities, the Contractor should submit a construction camp development/management plan to the Engineer-incharge and the	Design Consultant	SMTA

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	provide the estimated quantity of excavation material during the construction phase.	SEPA (if required) for its scrutiny and approval. As far as possible, vacant available land i.e. areas not under commercial or residential use and natural should be used for setting up the contractor camps.		
08	**Impact on Commercial, Moveable Structures and Livelihood** Different types of commercial structures, (plant nurseries, hotels, stores and moveable structures) will be impacted due to clearance of RoW for the project activities. The construction activity may disturb the business and livelihoods of the shopkeepers and workers doing their businesses along the alignment due to the excavation activities. There are various categories of commercial activities along the proposed bridge. The owners of the commercial structures will have a temporary impact on sources of livelihood until the re-establishment of their business in a new location. This impact will be, temporary and adverse in nature.	▪ Livelihood restoration plan in CLRP has been provided to mitigate the adverse impacts on livelihood and restoration of commercial activates will be monitored; ▪ Compensation of the structures should be evaluated and provided as per market rates; ▪ Affected Persons (APs) should be compensated on full replacement cost of each category to construct a new structure of the same type; ▪ Compensation of livelihood disturbance should be provided for the period of construction of commercial activities; ▪ The effort will be made through changes in design to avoid the sensitive and religious structures and to minimize the issues at possible extend. If needs demolishing, a mechanism will be developed for the restoration of these structures during the detailed design and during construction with the community consultation; and ▪ Proper consultations and coordination's with APs during resettlement process.	Design Consultant	SMTA
09	**Impact on Community and Religious Structures** The community and religious structures are very sensitive to impact and need special care during execution of the project because people are of the opinion that these	Effort will be made by making changes in design to avoid the sensitive and religious structures and to minimize this issue upto possible extent. If this issue is unavoidable, a mechanism will be developed for the restoration of these structures with the community consultation and religious leaders.	Design Consultant	CSDC & SMTA

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	structures might not be rebuilt if once demolished. A mosque falls in the required RoW of the proposed project. Shifting and demolishing of these structures may cause serious social issues.			
10	**Public Utilities** Due to the proposed Project, public utilities will be affected creating disruption of public services and inconvenience to the local residents. Various utilities such as electrical pylons, gas supplies telecommunication infrastructure, water supplies, drainage system and other important structures are situated within the CoI of the proposed project. These utilities will be relocated before the start of construction activities. These utilities if not handled properly will cause difficulties to the people of Project Area. This impact can be categorized as direct, site-specific, short term, temporary, low to medium probability and reversible.	▪ The provision of relocation/rehabilitation in the design and project budget for the relocation of the existing public utilities wherever required shall be finalized in consultation with the concerned department; ▪ During the pre-construction phase, close coordination between contractor, consultant and stakeholders of all utilities is necessary to avoid any mishaps at project site. In particular, wherever the PARCO, PRL, NRL,PTCL, SSGC, KE and KW&SB lines are lying, high level precautions shall be taken in liaison with these departments to avoid any possible damage which may impact the delivery of the project; ▪ Utilities shall be relocated and rehabilitated well ahead of start of construction works to avoid any inconvenience to the public; ▪ If utilities are accidentally damaged during construction, it shall be reported to the SMTA and utility authority, and repairs will be arranged immediately at the contractor's expense; ▪ The Project Team will conduct an extensive public information campaign and inform the public about any disruptions in advance, and their relocation/repair will be ensured in shortest possible time; and ▪ Timely public notification of unexpected disruption of services.	Design Consultant	CSDC & SMTA
Construction Phase				
01	**Traffic Management**	▪ A traffic management plan may be formulated with close coordination of SMTA and traffic police department and strictly	Contractor	MEC, CSDC &

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	Traffic problems may arise for the commuters and transporters travelling to the proposed areas. The problems will include traffic jams and inconvenience to the public passing through the project area. It will also increase traffic load on the access roads ultimately deteriorating the existing condition of the roads. The movement of vehicles along the haulage routes will cause soil erosion, debris flow, dust emissions, vibrational impacts, etc. Considering these consequences, this impact can be categorized as direct, moderate, site-specific, medium term, temporary, medium probability and irreversible. The impact significance is medium adverse.	implemented and monitored during the entire construction phase; ▪ Movement of vehicles carrying construction materials and equipment/machinery will be restricted during the daytime to reduce traffic load and inconvenience to the local population; ▪ Construction vehicles, machinery and equipment will be parked at designated areas (at construction camps site) to avoid un-necessary congestions along the major roads; ▪ The speed of the vehicles will be controlled (at 30 to 40 km/hr) to reduce the probability of severe accidents, soil erosion, debris flows due to vibrations and dust emission; ▪ Damages of roads due to construction vehicles will be instantly repaired and/or compensated after the completion of work; ▪ Proper sign boards should be provided for smooth flow of traffic; ▪ Period of construction and area / location of construction site shall be informed to public in general and specifically to local residents; and ▪ Any closure of the roads (especially main roads) and deviations / diversions proposed should be informed to the riders through standard signs and displays.		ESSU (SMTA)
02	**Resource Conservation** Resources involved in the construction of proposed Project would include water, fuel and construction materials. Excessive water consumption by the construction staff may stress water resources in the Project Area and in certain cases may disturb the existing water supplies in the	▪ Use potable water bowsers for construction works and mineral water bottles/ ground water for drinking purpose; ▪ Plan for the provision/purchase of adequate insulation to reduce heat loss through batching plants; ▪ Reduction of wastage of water through training of workers involved in water use; ▪ Reuse of construction waste materials may be adopted wherever possible;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	Project Area. Construction material to be used for construction includes coarse aggregates, fine aggregates, asphalt, cement, lining material, earthworks, reinforced and structural steel etc. Almost all the materials to be used in the construction of proposed Project are non-renewable and therefore their efficient use is necessary for the future use. Fuel will be used to operate construction machinery. Efficient use of energy resources is important to reduce air emissions. For conservation of energy, efficiency of the engines and burning processes is important.	▪ Diesel and fuels with low sulphur content should be used to operate construction machinery and equipment; ▪ The efficient and well maintained equipment and machinery should be used; ▪ The equipment and machinery should be turned off when not in use; ▪ Ensure adequate insulation to reduce heat loss through batching plants; • Regularly monitor CO and CO_2 content of the flue gases to verify that combustion systems are using practical excess air volumes; and • A good camp design and an efficient worksite management plan can help the contractor to reduce the water demand, wastewater and solid waste volumes to the lowest levels.		
03	**Community Health and Safety** Community health and safety issues during the construction of proposed project may include dust, noise, and vibration from construction vehicle transit, and communicable disease associated with the influx of temporary construction labor. Significant community health and safety issues associated with the project may also include: • Pedestrian safety	▪ Provision of safe corridors along the proposed bridge and construction areas, and safe crossings (preferably over or under the passage) for pedestrians and bicyclists during the construction phase. Crossing locations should take into account community preferences, including those related to convenience or personal safety; ▪ Installation and maintenance of speed control and traffic calming devices at pedestrian crossing areas especially near the settlements; ▪ Installation and maintenance of all signs, signals, markings, and other devices used to regulate traffic, specifically those related to pedestrian facilities or bikeways;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	• Traffic safety • Emergency preparedness The construction activities and vehicular movement at construction sites may result in roadside accidents particularly inflicting local communities who are not familiar with presence of heavy equipment. Quality of groundwater and surface water resources available in the nearby local communities may be affected due to the construction activities, oil spillage and leakage, roadside accidents, etc. The proposed project will also have potential of air (dust pollution), noise and vibration impacts on nearby community. The labor works with different transmittable diseases (HIV/AIDS, COVID-19, etc.) may cause spread out of those diseases in the local residents. The construction areas located near the residential/settlements may cause accident for the people moving near to these areas.	▪ Setting of speed limits appropriate to the road and traffic conditions; and ▪ An emergency preparedness and response plan in coordination with the local emergency service centres to provide timely first aid response in the event of accidents and hazardous materials response in the event of spills. ▪ Instruct foremen to strictly restrict the entry of un authorised persons, particularly children, from the construction sites; ▪ Timely public notification on planned construction works; ▪ Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity, access and social links; ▪ Reducing the impacts of vector borne diseases on long-term health effect of workers should be accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease, which includes: Prevention of larval and adult propagation of vectors through sanitary improvements and elimination of breeding habitat close to residential areas and by eliminating any unusable impounding of water; ▪ The communicable disease of most concern during construction phase, like Sexually-Transmitted Disease (STDs) such as HIV/AIDS, COVID-19 will be prevented by successful initiative typically involving health awareness; education initiatives; training heath workers in disease treatment; immunization program and providing health service.		
04	**Occupational Health and Safety** Occupational Health and Safety (OH&S) issues associated with the construction of proposed project will primarily include	IFC guidelines shall be followed for Occupational Health and Safety, however, in general following shall be considered; <u>Moving Equipment and Traffic Safety:</u>	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	physical hazards; chemical hazards; and noise. **Physical Hazards:** Construction workers can be exposed to a variety of physical hazards, principally from operating machinery and moving vehicles but also working at elevation on bridges and overpasses. Other physical hazards (e.g. exposure to weather elements, noise, work in confined spaces, trenching, contact with overhead power lines, falls from machinery or structures, and risk of falling objects). The falls during inspection or maintaining pile rigs, steel fixing during erection of framework and other related activities. Eye injury can be caused by stone or metal particles. Hazard of being hit by falling objects, major hand-arm and whole body vibration hazards, skin and respiratory tract irritation from exposure to cement dust, overexertion and awkward postures etc. will be another impact. Welding hazards include electric shock, fumes and gases, fire and explosions, falls from height, eye and head injuries etc.	▪ Establishment of work zones to separate workers on foot from traffic and equipment by; ▪ Routing of traffic to alternative roads when possible; ▪ Where worker exposure to traffic cannot be completely eliminated, use of protective barriers to shield workers from traffic vehicles, or installation of channelling devices (e.g. traffic cones and barrels) to delineate the work zone; ▪ Regulation of traffic flow by warning lights, avoiding the use of flaggers if possible; ▪ Reduction of maximum vehicle speeds in work zones; and ▪ Training of workers in safety issues related to their activities, such as the hazards of working on foot around equipment and vehicles; and safe practices for work at night and in other low-visibility conditions, including use of high-visibility safety apparel and proper illumination for the work space (while controlling glare so as not to blind workers and passing motorists). <u>Elevated and Overhead Work:</u> ▪ The area around which elevated work is taking place should be barricaded to prevent unauthorized access. Working under personnel on elevated structures should be avoided; ▪ Hoisting and lifting equipment should be rated and properly maintained, and operators trained in their use. Elevating platforms should be maintained and operated according to established safety procedures including use of fall protection measures (e.g. railings); equipment movement protocols (e.g. movement only when the lift is in a retracted position); repair by qualified individuals; and installation of locks to avoid unauthorized use by untrained individuals;		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	Other impacts will be fall from height, contact with heavy electrical and mechanical equipment, equipment failure, uncontrolled movement, unguarded moving mechanical equipment parts, fatigue, unbalanced load, falling objects, hand injury, slip and trip hazards, wind / storm activity, injury from releasing load too soon etc. Operating mechanical and electrical equipment will trigger the H&S issues e.g. struck by moving vehicles or other equipment, slips or trips, struck by flying objects, such as dirt or splashed fluids, caught in pinch points, shear points, crush points, falling from machine etc. The proposed Project Area is also sensitive from the law and order point of view and the security as well as the safety of the Contractor and Consultant staff will be a concern. ***Chemical Hazards*** in proposed project construction may be principally associated with exposures to dust during construction and demolition activities; exhaust emissions	▪ Ladders should be used according to pre-established safety procedures for proper placement, climbing, standing, as well as the use of extensions; and ▪ Provide appropriate personal protective equipment (PPE) in conjunction with training, use, and maintenance of the PPE. Fall Protection ▪ Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others; ▪ Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity)[1]. The fall protection system should be appropriate for the structure and necessary movements, including ascent, descent, and moving from point to point; ▪ Safety belts should be not less than 16 millimetres (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibres become evident; and ▪ When operating power tools at height, workers should use a second (backup) safety strap. Control of chemical hazards: ▪ Use of millers and pavers with exhaust ventilation systems and proper maintenance of such systems to maintain worker		

[1] IFC Environmental, Health, and Safety Guidelines-TOLL ROADS

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	from heavy equipment and motor vehicles during all construction activities; diesel fuel used as a release and cleaning agent for paving equipment and in generators; and handling and storage of bitumen. ***Noise:*** Construction and maintenance personnel may be potentially exposed to extremely high levels of noise from heavy equipment operation and from working in proximity to vehicular traffic. As most of these noise sources cannot be prevented, control measures should include the use of personal hearing protection by exposed personnel and implementation of work rotation programs to reduce cumulative exposure. In addition, disasters such as earthquakes and fires may occur. Lack of Emergency Response Plan (ERP) or an inefficient response plan may lead to an accident or critical injury.	exposure to crystalline silica (millers and grinders) and asphalt fumes (pavers) below applicable occupational exposure levels; ▪ Use of the correct asphalt product for each specific application, and ensuring application at the correct temperature to reduce the fuming of bitumen during normal handling; ▪ Maintenance of work vehicles and machinery to minimize air emissions; ▪ Reduction of engine idling time at active construction sites; ▪ Use of extenders or other means to direct diesel exhaust away from the operator; ▪ Use of protective clothing when working with cutbacks (a mixture of asphalt and solvents for the laying of pavement), diesel fuel, or other solvents; and ▪ Provide appropriate personal protective equipment (PPE) in conjunction with training, use, and maintenance of the PPE. Furthermore, the noise reduction options that should be considered which include: ▪ Selecting equipment with lower sound power levels; ▪ Installing suitable mufflers on engine exhausts and compressor components; ▪ Installing vibration isolation for mechanical equipment; ▪ Providing noise protection PPEs (ear plugs/ear muffs) to the construction workers; ▪ Re-locating noise sources to less sensitive areas to take advantage of distance and shielding; ▪ Developing a mechanism to record and respond to complaints; and ▪ Regular monitoring of noise levels at active sites or near noise producing equipment/machinery and compare it to the available occupational noise standards.		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ No employee should be exposed to a noise level greater than 85 dB (A) for a duration of more than 8 hours per day without hearing protection. [2] <u>Monitoring of OHS Activities:</u> ▪ During the construction phase of proposed project, occupational health and safety monitoring programs of the contractor (s) should verify the effectiveness of prevention and control strategies. The selected indicators should be representative of the most significant occupational, health, and safety hazards at the construction site and camps, and the implementation of prevention and control strategies. The occupational health and safety monitoring program should include: ▪ Regular inspection and testing of all safety features and hazard control measures focusing on engineering and personal protective features, work procedures, places of work, installations, equipment, and tools used; ▪ Surveillance of the working environment: The contractors should document compliance using an appropriate combination of portable and stationary sampling and monitoring instruments. Monitoring and analyses should be conducted according to internationally recognized methods and standards. Monitoring methodology, locations, frequencies, and parameters should be established individually for each Project following a review of the hazards; ▪ Continuous and efficient surveillance of worker's health during the entire construction phase by the nominated officials of contractors; and		

[2] IFC General Environmental, Health, and Safety Guidelines

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Training: Training activities for employees (construction contractor & supervision consultant staff) and visitors should be adequately monitored and documented (curriculum, duration, and participants). Emergency exercises, including fire drills, should be documented adequately. Service providers and contractors should be contractually required to submit to the employer/ adequate training documentation before start of their assignment. General Mitigation Measures for OHS of Workers and Community during Construction Phase: ▪ Complying with the safety precautions for the construction workers as per International Labour Organization (ILO) Convention No. 62, as far as applicable to the Project Contract; ▪ Formulation of layout plan for camp site, indicating safety measures taken by the contractor, e.g. firefighting equipment, safe storage of hazardous material, first aid, security, fencing, and contingency measures in case of accidents; ▪ Work safety measures and good workmanship practices are to be followed by the contractor to ensure no health risks for labourers; ▪ Provision of adequate sanitation, washing, cooking and dormitory facilities including light up to satisfaction; ▪ Proper maintenance of facilities for workers shall be monitored; ▪ Provision of protective clothing for labourers handling hazardous materials, e.g. helmet, adequate footwear for bituminous pavement works, protective goggles, gloves, etc. Ensure strict use of wearing these protective clothing during work activities; ▪ Contractor will ensure the provision of medicines, first aid kits, ambulance etc. at the camp site;		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Provision of proper safety and diversion signage, particularly at sensitive/accident-prone spots; and ▪ Disasters such as earthquakes, flooding, due to heavy rain and other manmade disasters such as fires may occur, and that must be considered for minimizing their impacts. Therefore, an Emergency Response Plan for earthquakes and manmade disasters should be developed in consultation with the construction contractor and Rescue Services. ▪ Construction Camp Management Plan (CCMP) and effective implementation of GRM may reduce this impact.		
05	**Air Quality** Air quality will be affected by dust fugitive emissions and debris from construction and demolition activities; unpaved surface and construction vehicles. Emissions may be carried over longer distances depending upon the wind speed, direction, temperature of surrounding air and atmospheric stability. Air pollution will be generated mainly from the following activities: ▪ Site clearance and Demolition of existing bridge will result in dust and debris contributing in standard particulate matter (PM_{10} and $PM_{2.5}$); ▪ Procurement transport and handling of construction materials such as sand, cement, etc. to the construction site;	▪ All vehicles, machinery, equipment and generators used during construction activities should be kept in good working condition and be properly tuned and maintained in order to minimize the exhaust emissions; ▪ Open burning of solid waste from the Contractor's camps and at construction site should be strictly banned; ▪ Preventive measures against dust should be adopted for on-site mixing and unloading operations. ▪ Construction materials (sand, gravel, and rocks) and spoil materials will be transported trucks covered with tarpaulins and all vehicles (e.g., trucks, equipment, and other vehicles that support construction works) will comply with the SEQS (as amended) for carbon emissions and noise; ▪ Regular water sprinkling of the site should be carried out to suppress excessive dust emission(s); ▪ Emissions from power generators and construction machinery are important point sources at the construction sites. Proper maintenance and repair is needed to minimize the hazardous emissions; and ▪ Construction equipment is generally left idling while the operators are on break or waiting for the completion of another	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	▪ Other Gaseous emissions during construction result from operating of construction vehicles, plant and equipment (asphalt and batching plants); The construction and demolition activities may impact the sensitive receptors along the corridor, surrounding communities and workers. The overall impact on the quality of air during the construction phase will, however, be temporary and limited to the project's implementation phase. This impact can be categorized as direct, moderate, site-specific and short term. The impact significance is medium adverse.	task. Emissions from idling equipment tend to be high. Existing idling control technologies, which automatically shut the engine off after a priest time can reduce emissions, without intervention of the operators. ▪ SEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery should be enforced during construction works. ▪ Service roads (used for earthmoving equipment and general transport) should be regularly sprayed with water during dry weather; ▪ Construction workers should be provided with PPEs masks for protection against the inhalation of dust; ▪ Vehicles used for construction should be tuned properly and regularly to control emission of exhaust gases. ▪ Ensure precautions to reduce the level of dust emissions from hot mix plants, crushers and batching plants should be taken up; e.g. providing them as applicable, with protection canvasses and dust extraction units. Mixing equipment should be well sealed and equipped as per existing standards; and ▪ Regular monitoring of air quality in accordance with SEQS.		
06	**Noise** Noise will be generated from construction and demolition activities e. g: movement of heavy traffic and construction equipment. The likely impacts due to noise are: ▪ Psychological effects of distraction of attention, irritation and short temperedness in the exposed persons due to persistently higher noise levels; and	There are a variety of ways by which construction equipment and worksite noise can be controlled. The following is a list of ways to control noise level at the worksite of the proposed Project: ▪ Quieter Equipment ▪ Modifying Existing Old Equipment ▪ Barrier Protection ▪ Work Activity Scheduling ▪ Maintenance of machinery ▪ Noise Perimeter Zones	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	▪ Noisy settings and higher background levels can cause temporary threshold shift and the consequent habit of speaking loud, which may cause damage to vocal cords in the persons exposed.			
07	**Soil Contamination** During the rain, the eroded soil can affect movement of vehicles, machinery and construction work as well as limit the movements of local people. Heavy metals, oils, other toxic substances and debris from construction and demolition, movement of traffic and spillage may be absorbed by soil at construction sites and carried with runoff water to Malir River. It may be of more concern during the monsoon. Whereas, contamination of soil may be caused by oil and chemical spills at asphalt plant sites, workshop areas and equipment washing yards.	▪ All spoils should be disposed of at site designated by Karachi Metropolitan Corporation (KMC) or concerned department and the site should be restored back to its original conditions; ▪ Non-bituminous wastes from construction activities should be dumped in approved sites, in line with the legal prescriptions for dumpsites, and covered; ▪ Soil contamination by asphalt should be minimized by placing all containers in caissons; ▪ The Contractors will be required to instruct and train their workforce in the storage handling and management of materials and chemicals that can potentially cause soil contamination; ▪ Material Safety Data Sheets (MSDS) will be strictly followed during handling and storage of chemicals; ▪ If any contaminated soils are found at the construction sites or at camp sites, they shall be removed and deposited in a sealed pit in an area agreed/approved from the concerned city government department (e.g. KMC).	Contractor	MEC, CSDC & ESSU (SMTA)
08	**Soil Erosion** Construction and demolition activities such as clearing of earth, levelling, compaction, carpeting, pavement finishing will affect the	▪ The contractor should adopt good engineering practices that will help to control or minimize the soil erosion both at the construction sites and in peripheral areas. All the disturbed areas need to be protected against soil erosion by stripping and stockpiling of all the available topsoil for later re-vegetation.	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	existing soil condition in the CoI. The clearing of vegetation can also loosen the soil and make it more susceptible to erosion due to wind and rain. There is also a possibility of silt runoff during the monsoon causing soil erosion. Soil erosion may also occur in the workshop areas as a result of improper drainage system of equipment washing-yards and improper management of construction activities.	Special slope protection measures will be adopted in the sensitive areas and along the proposed bridge. ▪ Use of stone pitching or riprap will also be provided in the design at appropriate places. Provision for rip-rap in discharge zones from drainage structures may be made to reduce erosion; and ▪ Down drains/chutes may be lined with rip-rap/masonry or concrete to prevent erosion. Side slopes may be adjusted to a gradient necessary to reduce erosion potential or, if steeper, stabilized, covered with riprap or other material to prevent soil erosion.		
09	**Wastewater Generation at Construction Camps** Wastewater will be generated at the construction camp and construction site from construction activities. If the generated wastewater is not properly treated or disposed of, this may contaminate the Malir River apart from soil contamination. Water from dewatering activities (during rainy season) has the potential to contain suspended solids and oil and grease and if disposed of untreated may affect the soil quality.	▪ Domestic and chemical effluents from the construction camp will be disposed by the development of on-site sanitation systems i.e. septic tanks. Proper monitoring to check the compliance of SEQS will be carried out; ▪ Sewage from construction camps will be disposed of after proper pre-treatment and processes such as soakage pit; ▪ Construction yards and material storage areas where vehicles operate or materials are stored should be established on well drained fill; ▪ Free-flowing points of discharge for storm water should be identified nearby the boundaries of materials storage/construction yards for gravity or pump-assisted dewatering and yard drainage; ▪ Local drainage channels should have sufficient capacity for handling discharge flows, with clear discharge points to open drainage courses; ▪ Water discharged to constructed drains should contain a minimum quantity of suspended solids;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Temporary worker quarters and erection yards should include self-contained waste treatment with removal of excess by vacuum truck or approved discharge point; ▪ Drainage from fuel storage tank locations, refuelling areas, and equipment service areas should be segregated from other runoff; discharge should be routed through an oil/water separator; and ▪ Contractors will be required to observe drainage conditions during dewatering operations and storm events to assure positive drainage. If flooding occurs along roadways or in neighbourhoods, or community complaints arise, the contractor will undertake a combination of the above mitigation measures to minimize drainage and water quality impacts.		
10	**Solid Waste Generation at Construction Camps** The major components of the labor camp waste will be garbage, putrescible waste, rubbish and small portion of ashes and residues. Other type of wastes may include inorganic construction wastes including hazardous waste. These wastes will be generated due to the construction activities and the materials used for construction. This waste would require proper disposal to minimize land and water contamination.	▪ All the solid waste from the camps will be properly collected at source by placing containers and disposed of through proper solid waste management system. The Contractor will coordinate with local representatives and administration concerned department for the disposal of solid waste; ▪ The concerned department must develop a plan of action for transporting the waste to the disposal site for final disposal. It is the responsibility of the concerned department to ensure that the disposal site is properly lined to prevent the leachate from contaminating the groundwater; ▪ Secondly, the disposal site must be located away as far as practical from populated areas and regions that have a high density of Wildlife; ▪ Toxic waste will be handled, stored, transported and disposed separately; ▪ The waste will be properly sealed in containers with proper labels indicating the nature of the waste; ▪ Solid waste will be segregated at source so that it can be re-used or recycled; and	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Contractors are required to prepare a Solid Waste Management Plan that identifies the following: material types, estimated quantities and methods for disposal; locations onsite for collection and storage; locations for disposal. A record keeping system for all wastes and a tracking and manifest system for hazardous and recycled materials will be included in the plan. Necessary enclosed facilities, containers and equipment will be provided in keeping with the Plan. The Plan should be updated as necessary with actual quantities, locations for disposal and additional information in accordance with the Plan.		
11	**Waste Generation at Construction Site** Waste from construction site includes construction and demolition waste. The demolition waste may include concrete, bricks, asphalt, etc. Waste generated from construction activities may include wastewater, oil spillage from machinery and solid waste (damaged or spoiled materials, temporary and expendable construction materials etc.). The handling and storage of oil and other hazardous waste will be a source of environmental pollution during the excavation, foundation, levelling, carpeting and pavement activities. The solid and liquid waste from the batching plant setup in the vicinity of construction camps may also generate along with the above waste stream.	▪ Waste Management Plan will be developed to implement an efficient and responsive solid waste management system during construction phase. ▪ Recyclable wastes e.g. steel bars will be sold to waste vendors; ▪ The contractor will develop specific environmental management plans for asphalt plants and concrete batching plants. These plans will incorporate the general measures as applicable to the entire Project, but will also have focused mitigations for solid waste from these plants; ▪ Waste generated from demolition shall be reusable or recycled as far as practically possible; ▪ Solid waste generated during construction will be safely transferred to the designated waste disposal sites of Karachi (specifically Malir District) after getting the prior approval from the KMC and the approved contractor will provide a proper waste management plan for safe transfer as well as disposal of this waste; and ▪ The site will be restored back to its original conditions after construction completion.	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	Concrete and asphalt have limited usable life, after which they become waste. If not used within the time span, their wastage will have major financial implications. Further, their disposal will become very difficult because of the large quantities involved. Improper disposal of construction waste can lead to nuisance and hazards towards environment and local population. The unspent materials and debris produced from consumed up materials, if left as such and allowed to mix with soil underneath, can degrade the quality of receiving soils and render them unfit for plantation. Leakages of oils, lubricants, chemicals, and other similar substances from their storage sites can spoil the receiving soils and may undermine ability of the spoiled soils to support growth of vegetation and plants.			
12	**Borrow Pits** The site for borrow pits / quarry areas has not been identified at this stage of the Project. Hence, the impacts discussed for borrow pits/ quarry areas are of generic nature. Borrow/ open pits and its excavation activities may result in land disputes, soil	▪ It is suggested that during the planning stage of quarry development the groundwater level be defined so the quarry floor can remain at least 2 meters above groundwater; ▪ In borrow pits, the depth of the pits will be regulated so that the sides of the excavation will have a slope not steeper than 1:4; ▪ Soil erosion along the borrow pit will be regularly checked to prevent/ mitigate impacts on adjacent lands;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	erosion, loss of vegetation, landscape degradation, and damage to road embankments. Borrow pits may also result in potential sources of mosquito breeding and may prove hazardous to human beings.	▪ Determine the intended future-use and final landform of a site at an early stage. This should be in consultation with the landowner and broader community (for a larger quarry); ▪ When siting a quarry, existing natural features should be used to conceal the quarry and limit the visual impact; ▪ Plan sequencing of both quarrying and rehabilitation for the life of the quarry; ▪ Borrow pits may be used for construction waste, but during the excavation, top 20 cm soil cover will be preserved for vegetation after the filling of the pits. This is the best way to restore the flora of that area; and ▪ Prior to the commencement of a quarrying activity the type of vegetation should be agreed with the landowner, and should be consistent with the proposed final land-use.		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
13	**Impact on Water Resources (Surface and Groundwater Contamination)** The proposed project will also pass through the Malir River, These surface water bodies may get contaminated by the fuel and chemical spills due to construction activities, or by solid waste and effluents generated by the kitchens and toilets at the construction camp sites. Furthermore, surface water might also get contaminated due to the disposal of construction and demolition waste generated during the project activity at these water bodies, increasing sediment load which will result in jeopardizing the health of locals that use this water for meeting domestic requirement. The impact on these water bodies will be only for the period of construction and will eliminate as the construction work is over. In addition to that, construction waste, if left unattended will result in forming leachate which may percolate through the soil strata and will reach underground water table and hence, will end up contaminating it.	As a mandatory step, all the effluents will be disposed as per the requirements of SEQS and applicable IFC/WHO Standards. Moreover, to reduce the risk of surface and groundwater contamination, good management practices will be adopted to ensure that fuels, chemicals, raw sewage and wastewater effluent are disposed of in a controlled manner. These measures are described below: ▪ Construction camps will be established in areas with adequate natural drainage channels in order to facilitate the flow of the treated effluents after ensuring that SEQS are met; ▪ The surface and groundwater reserves will be adequately protected by installing screens and barriers to protect the source of contamination such as construction and oily waste that will degrade its potable quality; ▪ The proponent will ensure that the construction work is confined within the RoW and water bodies are prevented from pollution during construction; ▪ The solid waste will be disposed of in designated landfill sites to sustain/protect the water quality for domestic requirements; ▪ Regular water quality monitoring according to determined sampling schedule; ▪ The contractor will ensure that construction debris do not find their way into the rivers, drainage or irrigation canals which may get clogged; ▪ Work on irrigation canal areas will be kept to a minimum, protective wall be constructed; ▪ To maintain the surface water flow/drainage, proper mitigation measures will be taken along the road, like drainage structures in urban areas;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Prohibit washing of machinery and vehicles in surface waters, provide sealed washing basins and collect wastewater in sedimentation/retention pond; ▪ Construction work close to the streams or other water bodies will be avoided, especially during monsoon period; and ▪ Wastes will be collected, stored and taken to approved disposal site. ▪ Wastewater effluent from the Contractors' workshops and equipment washing-yards will be passed through gravel/sand beds to remove oil/grease contaminants before discharging into the natural streams. According to the SEQS, the BOD concentration in sewage must be brought down to less or equal to 80 mg/l before being discharged into a natural stream having capacity to dilute the effluent. For wastewater, apart from BOD, COD of 150 mg/l will also be checked; and ▪ Similarly, if the sewage after treatment is to be discharged on to the land it will meet the requirements of the SEQS for disposal of wastewater.		
14	**Flora** Tree growth in the Project Area is scattered and scanty. The natural vegetation is long ago replaced by commercialization and high anthropogenic pressure. Therefore, the impact shall also be proportionately low. During the entire construction period dust laden polluted air will form a dust film on leaves thus blocking the stomata	▪ Cutting of trees and disturbance of green areas shall be avoided, as far as possible so that negative effects on the process of natural regeneration of species are minimized and possible alternate route must be considered for proposed project, in which minimum ecological and environmental losses are expected; ▪ Utmost effort shall be made to save as many trees as possible and minimize the loss of vegetation.	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	consequently hindering photosynthesis processes causing detrimental effect on the plant health. Sprinkling and watering the plants in the project areas and in the vicinities is high recommend. Exhaust of noxious gases from movement of heavy machinery and dust will pollute air which will adversely affect health and vigor of plants. During construction activities the Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements). Removal of trees shall have an adverse effect on the ecological habitat of the Project Area.	▪ An awareness campaign targeted on the neighbourhood masses should be run to popularize the planting of trees species especially recommended in tree plantation plan ▪ The contractor's staff and labor should be strictly directed not to damage any vegetation such as trees or bushes. They should use the paths and tracks for movement and should not be allowed to trespass through farmlands; ▪ Construction vehicles, equipment and machinery should remain confined within their designated areas of movement; ▪ Contractor should supply gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel should not be allowed; and ▪ Camp sites and asphalt plants should be established on waste/barren land rather than on forested or agriculturally productive land. However, if such type of land is not available, it should be ensured that minimum clearing of the vegetation is carried out and minimum damage is caused to the trees.		
15	**Fauna** During construction phase the existing population of small mammals and reptiles of the construction areas will be affected due to disturbance arising from construction activities involving excavation, movement of machinery and vehicular traffic, movement of labor, camping, etc. The existing animals will leave the directly affected areas due to construction activities and human intervention. Some animals particularly reptiles may get killed during the earthworks	▪ Plantation of large number of trees along the proposed Project to regain the ecological habitat; ▪ New and good condition machinery with minimum noise should be used in construction; ▪ Noisy work should not be carried out in night time so that there should be no disturbance to local birds and animals; ▪ Contractor should ensure that the no hunting, trapping of animals should be carried out during construction; ▪ Borrow pits should be fenced so that no animal can fall into these; ▪ The camps should be properly fenced and gated to check the entry of wild animals in search of eatable goods. Similarly, waste of the camps should be properly disposed of to prevent the	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	operations. Moreover, the movements of the mammals and reptiles will be restricted during the construction phase. Birds as well, will tend to move away from the construction areas and find shelter and food elsewhere due to the activities mentioned above for fear of being hunted / trapped. Noise generated from working and machinery particularly during the night hours will even scare the wildlife residing in habitats located at some distance from the construction areas. Uncontrolled excavation may even disturb the wildlife of the Project Areas. Food at the Contractor's camps may attract animals that might in turn be hunted by the workers.	chances of eating by wild animals, which may prove hazardous to them; ▪ Special measures should be adopted to minimize impacts on birds such as avoiding noise generating activities during the critical period of breeding; ▪ Shooting, hunting, trapping or poaching of animals and birds should totally be banned within the Study Area, so as to minimize loss of fauna ecosystem. Implementation of such a policy will be the sole responsibility of concerned Government Departments; ▪ Care shall be taken during construction activities for avoiding purposely or chance killing of animals; ▪ If found any wild species and habitat during construction, it must be dealt carefully and local wildlife department officials should be informed; ▪ Hunting, poaching and harassing of wild animals shall be strictly prohibited, and Contractor shall be required to instruct and supervise its labor force accordingly and clear orders should be given in this regard; and ▪ The Contractor must be held responsible for instructing his work force accordingly and for enforcing this restriction. In addition, this shall have to be controlled by the Wildlife Department.		
16	**Aquatic Fauna** In order to define the categorization of aquatic habitat the different standards were followed through extensive literature review supported by focus group discussions, stakeholder consultations, field observations/verifications and GIS mapping. Based on the ground realities and values,	Industrial community may be forced to treat the effluents properly before releasing into the river. Proper culverts must be constructed at the rain water entries into the river. Proper arrangements must be made to control the wastes from machinery & equipment used at site during the construction phase. Enforcement of SEPA Rules and Regulations to control release of toxic and untreated effluents of the industries to avoid increase of the	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	there are two types of fish species. These are **Tilapia (Oreochromis mossambicus** and **Channa** punctate. Furthermore, the Malir River is a non-perennial river which mostly caters the wastewater from the various point and non-point sources. The quality of Malir River is much degraded that it does not support any critical aquatic life including zooplanktons. In addition to that, the identified species commonly survive under harsh conditions (deteriorated water quality). Therefore, considering these scenarios, there is no direct significant impact on aquatic life of Malir River in the Project Area vicinity. However, there is an indirect impact on the aquatic life of mangrove area downstream if oil and wastes from the machinery and equipment of the construction are released in the river. **Seasonality** There are two main seasons in Karachi, summer and winter. Spring and autumn seasons are very nominal. The Malir River upstream of the Project Area generally remains dry due to drought and barani small dams (Mol Dam, Sukhan Dam, Mir Chakar	toxicants in the Malir River so that the water bodies there remain safe even in the dry season. Channa punctatus, the fish species in the Project Area require the salinity level less than 10 mg/liter for its survival and proper growth. Increase in the salinity level will stop its breeding activities and the biodiversity will disturb. Construction of proper culverts for free flow of the rain and sewage water is strongly recommended to maintain the aquatic biodiversity in the area.		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	Dam, Konkar Dam, Malir Bukhsan Dam, etc.) in its catchment area. These small dams receive the rain water of the catchment area. The Malir dam regulates flow and flooding of the river, preserving a reservoir during seasonal droughts. The river of the Project Area receives mostly the industrial and urban sewage water which is highly polluted and unable to survive fish /aquatic life except some plants / bacteria and two types of fish (Tilapia and Channa punctatus). So as the seasonality effects of the river on aquatic ecology are concerned, these are not significant. During the survey and study of the Malir River in the project area two fish species and marshy grasses were identified which may have adverse impacts of the proposed Project if proper mitigation measures are not ensured.			
17	**Loss of Income** The construction activity may disturb the business and livelihoods of the shopkeepers and workers doing their businesses along the alignment. There are various categories of commercial activities along the proposed project.	▪ Proper compensation to all the affectees losing their livelihoods along the route; and ▪ Engage stakeholders in livelihood restoration measures including affectees of the project. A separate compensation and livelihood rehabilitation plan is being updated	Contractor	SMTA

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
18	**Restriction of access and mobility** ▪ Local residents and business operators will face difficulties getting access to their business places and residences; ▪ This will result in causing inconvenience to the residents/pedestrians and affect their daily activities. It may also reduce the frequent interaction between families; and ▪ Increased heavy traffic (construction vehicles) on public routes.	▪ Maintaining regular communication with local communities and other stakeholders to minimize tensions arising from Project activities; ▪ Construction activities should be carried out segment wise; ▪ Construction related activities will be minimal and temporary at any one location along the project corridor and would be similar throughout the corridor; ▪ Contractors should keep community members apprised of construction schedules in readily accessible public locations as well as on the SMTA website, and seek community input when developing construction plans; ▪ A traffic management plan will be prepared for this purpose as part of the EMP; ▪ The contractor must identify the impacts and address them during the construction phase; and ▪ Timely completion of the construction activities as per schedule	Contractor	MEC, CSDC & ESSU (SMTA)
19	**Influx of Labor** • Risk of social conflict: • Increased risk of illegitimate behavior and crime • Impacts on community dynamics • Increased burden on and competition for public service provision: • Increased risk of communicable diseases and burden on local health services • Local inflation of prices, accommodations and rents: • Increase in traffic and related accidents	▪ Labour camp(s) should be established away from residential population; ▪ Preference should be given to the local people to work with contractor, and contractor should hire maximum labour force from the project area because this will reduce the labour influx; ▪ Awareness should be created among the work force to ensure respect for local customs; ▪ Construction work should be completed within the stipulated time to move workers to next location; ▪ Labor force should be shuffled with the time; ▪ An effective GRM should be established for the project to resolve all issues related to the community. Thus, progress regarding resolving the issues should be monitored closely;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
		▪ Create awareness among workers on proper sanitation and hygiene practices to endorse proper health and maintain good housekeeping practices at all project sites; ▪ Provide adequate personal hygiene facilities in good condition with adequate supply of clean water; ▪ Make arrangements to treat the affected workers on time to control the movement of vector borne diseases; ▪ Sensitize workers and surrounding communities on awareness and prevention of COVID-19, HIV/AIDS and sexually transmitted infections (STI) through training, awareness campaigns and workshops during community meetings; ▪ Provide proper and free COVIID-19, HIV/AIDS and STI health screening and counseling for site workers and community members; ▪ Develop and enforce a strict code of conduct for workers to regulate behavior in the local communities; ▪ Taking all sensible precautions to avert illicit, vicious conduct by or amongst the Contractor's personnel, and to preserve unity and harmony, and protection of people and property on and near the sites; ▪ Prohibiting drugs, alcohol, weapons, and ammunition on the worksite among personnel; ▪ Site security preparations must be contained within the Bills of Quantities (BoQs) to avoid any delays which might be caused due to insecurity; ▪ Appropriate fencing, security check points, gates and security guards should be provided at the construction sites to ensure the security of all plant, equipment, machinery and materials, as well as to secure the safety of site staff; and ▪ The Contractor must guarantee that good relations are maintained with local communities and their leaders to help reduce the risk of vandalism and theft.		

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
20	**Communicable Diseases** The laborers in the Contractor Camp, truck drivers and like personnel who interact with each other have the potential for the spread of communicable diseases like COVID-19 and HIV/AIDS. Majority of the people living in the surrounding of the project, and potential labor are not aware of the source, mode of communication or consequences of HIV/AIDS. Although their religious and cultural value system, to a large extent excludes the outbreak or rapid communication of COVID-19 and HIV/AIDS, yet its occurrence in such a situation cannot be precluded. It is necessary that awareness and preventive campaigns are run from time to time in the labor camps and the field offices of the Project to prevent the communicable diseases. There is a chance of spreading of an epidemic of Coronavirus disease (COVID-19) due to close interaction of the labor force during construction not only among the workers but also in the area.	▪ Arrange to run an active campaign, in the labour camp, to make people aware of the cause, mode of transmission and consequences of HIV/AIDS; ▪ SOPs related to the disinfection and environmental decontamination advised by National Action Plan for COVID-19 Pakistan to control spreading of COVID-19, shall be implemented by the contractor and should be strictly monitored; ▪ Strengthen the existing local health and medical services for the benefit of labour as well as the surrounding villages; ▪ Ensure cleanliness and hygienic conditions at the labour camp by ensuring proper drainage and suitable disposal of solid waste. Inoculation against Cholera will be arranged at intervals recommended by the Health Department; ▪ Locating a labour camp at least away from the villages (local settlement), and ▪ Keep all the camps, offices, material depots, machinery yards and work sites open for the inspection of health and safety measures and related documents.	Contractor	MEC, CSDC & ESSU (SMTA)
21	**Gender Issues** Construction workers are predominantly younger males. Those who are away from	▪ The contractor will be required to provide qualified key personnel to address the specific risks identified in the project. Contractors will specify key staff with the technical skill and experience to implement the mitigation measures;	Contractor	MEC, CSDC &

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	home on the construction job are typically separated from their family and act outside their normal sphere of social control. This can lead to inappropriate and criminal behavior, such as sexual harassment of women and girls, exploitative sexual relations, and illicit sexual relations with minors from the local community. A large influx of male labor may also lead to an increase in human trafficking whereby women and girls are forced into sex work. During construction phase gender based violence might arise due to discrimination made against women by unequal work distribution and unequal pay structure among others. Sexual harassment against women might occur as a consequence of mixing of men and women at the construction site, and moving on the roads, bus stops and markets. Educational institutions near the project alignment are also sensitive regarding gender issues.	▪ The bidding documents will include specific requirements that minimize the use of expatriate workers and encourage hiring of local workers, thereby minimizing labor influx; ▪ The bidders will be required to submit Codes of Conduct (CoCs) with their bids. The CoCs will set clear boundaries for acceptable and unacceptable behaviours of all individuals and companies and will be signed by companies, managers and individuals; ▪ All project consulting firms will also be required to submit Codes of Conduct with their proposals; ▪ The contractor will be required to establish anti-sexual harassment policies that governs conduct in the workplace; ▪ The contractor will be required to provide mandatory and repeated training to workers on GBV sexual exploitation and abuse and HIV/AIDS prevention and on the content and obligations derived from the code of conduct; and ▪ Provisions will be set in contracts for dedicated payments to contractors for Sexual Exploitation and Abuse prevention activities (e.g. training) against evidence of completion. The portion of the contract price will be guaranteed by a performance security linked to environmental and social contractor performance. ▪ Conduct project stakeholder consultations throughout project implementation ▪ Put in place GBV sensitive GRM Develop worker camp management plan		ESSU (SMTA)
22	**Child Labour** Inhabitants of the project area have mix economic background and different sources of income. Children of low income groups mostly involve in different earning activities,	▪ Awareness should be created among the local communities about the adverse impacts of child labour. For the public awareness, meetings should be held in the Project Area, and announcements should be made using the available local platforms with the involvement of all sectors of the society;	Contractor	MEC, CSDC & ESSU (SMTA)

Sr. No	Impacts	Mitigation Measures	Responsibility	
			Implementation	Monitoring
	as their parents prefer to get their children hired in small shops as helpers, and waiters in hotels for earning money, and supporting household livelihoods. Increased opportunities for the host community to sell goods and services to the incoming workers can lead to child labor to produce and deliver these goods and services, which in turn can lead to enhanced school dropout.	▪ Contractor through contractual agreement should be bound to follow the labor standards, rules and regulations during hiring the labor force and all activities should be monitored by the social and environmental staff of the implementing agency; ▪ Client and Supervision consultant should ensure that contractor shall have its employment policy in accordance with relevant act and labour policies in Sindh and Pakistan; and ▪ Contractor should ensure the presence of all persons at site are adults and have their proper identity cards with them.		

1.6 MONITORING PLAN

Monitoring Plan is also associated with mitigation plan during the different stages of the project to ensure that mitigation measures are being effectively implemented. The contractor will carry out the monitoring at the field level on a continuous basis while MEC will validate the monitoring plan of contractor.

Monitoring Mechanism

Safeguard monitoring is an essential tool for assessing whether the adopted environmental and social management measures are meeting their stated objectives. Two complementary methodology shall be applied to monitor the proposed actions under the ESMP:

- Compliance monitoring: To check the compliance of actions proposed by the ESMP by visual observation, photographic documentation and the use of checklists etc.; and
- Effects monitoring: To monitor the consequences of program/activities on the biophysical and social environment; as applicable, the effects are repeatedly measured by applying selected indicators.

Monitoring will be carried out to ensure that the mitigation plans are regularly and effectively implemented. It will be performed at three levels. SMTA through ESSU will ensure ESMP monitoring regularly to ensure that the mitigation plans are being effectively implemented. Monitoring and Evaluation Consultant will monitor regularly the mitigation plans are being effectively implemented. At contractor's level, the environmental monitoring checklist will be filled on daily basis by their environmental manager.

Monitoring Plan

Monitoring plan during pre-construction and construction phases of the project is proposed **(Table 1.2)** to establish the baseline condition and ensure contractors compliance with the mitigation measures and evaluation along with the monitoring indicators and frequency.

Table 1.2: Environmental Monitoring Plan

Sr. No.	Receptor	Monitoring Parameters / Performance Indicator	Locations	Monitoring Mechanism	Monitoring and Reporting Frequency
1	Water Resources/ Water Quality	Compliance with all parameters as per SEQS.	Along the alignment of Jam Sadiq Bridge: Sampling from Malir River. However, one (01) surface water sampling locations are identified; Similarly, two (02) drinking water samplings points are identified. Other proposed effluent discharge points are: – Contractors camps – Concrete preparation plants – Fuel (Petrol. Oil and Grease) products storages.	Visual checks of laboratory activities Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring.	Once before the start of construction activity monitors and reported. On quarterly basis during the construction
2	Soil Contamination	Soil contamination, uncontrolled solid waste disposal activities at sites.	Along the alignment of Jam Sadiq Bridge. – Sites with severe contamination. Other proposed sampling sites are: – Construction Camp.	Visual observations and checks of laboratory activities Sampling and laboratory testing for soil samples.	Once before the start of construction by activity monitors and reported On quarterly basis during the construction

Sr. No.	Receptor	Monitoring Parameters / Performance Indicator	Locations	Monitoring Mechanism	Monitoring and Reporting Frequency
			– Spillage points of fuel, chemicals and lubricants.		
4	Dust Emissions	Compliance with SEQS	Along the alignment of Jam Sadiq Bridge Sensitive receptors within the CoI. Estimated sampling points are two (02).	Visual checks of laboratory activities. Onsite Ambient Air Monitoring equipment	Once before the start of construction by activity monitors and reported On quarterly basis during the construction
5	Noise Pollution	Compliance with dBA Leq. as per SEQS	Along the alignment of Jam Sadiq Bridge Sensitive receptors within the RoW/CoI. Estimated sampling points are two (02).	Visual checks of laboratory activities Monitoring of noise level at site.	Once before the start of construction by activity monitors and reported On quarterly basis during the construction
6	Fumes and gases	Monitoring of CO, CO_2, SOx, NO_x, HC and $PM_{2.5}$ PM_{10} and compliance with SEQS. Vehicular emissions as per SEQS	Along the alignment of Jam Sadiq Bridge – Major receptors within the RoW/CoI. Estimated sampling points are two (02) – Emissions from the silencers of heavy machinery, trucks and other vehicles.	Visual checks of laboratory activities Onsite monitoring of ambient air quality will be preferred.	Once before the start of construction by activity monitors and reported On quarterly basis during the construction

Sr. No.	Receptor	Monitoring Parameters / Performance Indicator	Locations	Monitoring Mechanism	Monitoring and Reporting Frequency
7	Public Infrastructure	Disturbance or damage to public infrastructure	Along the alignment of Jam Sadiq Bridge – Public infrastructures within the RoW/CoI. These infrastructure will be verified prior to the start of construction.	Random visits and consultations with AP's.	Prior to the start of construction. Reporting will be done on the basis of CLRP recommendation.
8	Community around the Project corridor	Use of common resources. Hindrance to mobility. Community health and safety	Communities within the RoW/CoI.	Community consultations.	Prior to the start of construction and during the construction phase. Reporting will be done on the basis of CLRP recommendation.
9	Labour Management	Child labour, Employment conditions, Workers' accommodation, Housekeeping, HIV/STDs, COVID 19 etc.	At construction camps	Site visits Consultations with staff and medical check-ups	Daily
10	Labour Influx	Conflicts related to labour influx	At construction camps Communities within the RoW/CoI.	Consultations.	Daily
11	Grievances Redressal	Type and number of grievances	At construction site	Complaint register	Daily

Sr. No.	Receptor	Monitoring Parameters / Performance Indicator	Locations	Monitoring Mechanism	Monitoring and Reporting Frequency
12	Health & Safety	Type and number of accidents	Construction site Construction camp Community concerns related to construction activity	Consultations and complaint register	Daily
13	Gender Based Violence	Number of incidents of harassment	Construction site Construction camp	Community consultations	Daily
14	Training	Community/occupational health and safety and Gender in-equalities	Construction site Construction camp	Consultations and training record	Biannual and/or as required during construction period.

1.7 CHANGE MANAGEMENT PLAN

The present ESIA has been carried out on the basis of the Project information available at this stage. It is however possible that the changes are made in some components of the project during the design and construction phases. In order to address the environmental and social implications of these changes, a simple framework has been devised, which is described in this section. The change management framework recognizes the three broad categories (A, B & C) of the changes in the Project as detailed below:

Category 'A' Change

The 'Category A' change is one that will lead to a significant departure from the project described in the ESIA and consequently requires a reassessment of the environmental and socioeconomic impacts associated with the change. In such an instance, Client will be required to conduct a fresh ESIA of the changed aspect of the Project design and send the updated report to the relevant agencies for approval.

Category 'B' Change

The category 'B' change is one that will entail project activities not significantly different from those described in the ESIA, which may result in the project effects with overall magnitude to be similar to the assessment made in this report. In case of such changes, the ESIA will be required to reassess the environmental and socio-economic impacts of the activity, specify additional mitigation measures, if necessary and report the changes to the relevant agencies.

Category 'C' Change

A Category-C change is one that is of little consequence to the ESMP findings such as change in alignment. This type of change does not result in effects beyond those already assessed in the ESIA; rather it may be made onsite to minimize the impact of an activity, such as re-aligning a particular section to avoid cutting a tree or relocating construction campsites to minimize clearing vegetation. The only actions required for such changes are informing all the key personnel and document the change.

1.8 CAPACITY BUILDING/STRENGTHENING

The environmental and social trainings will help to ensure that the requirements of the ESMP are clearly understood and followed by all project personnel. The primary responsibility of providing these trainings to all project personnel will be that of the contractor and SMTA. The trainings will be provided to different professional groups separately such as managers, skilled personnel, unskilled labors, and camp staff. Capacity building will be aimed at strengthening the operational staff in the field of environmental management and social development. The contractor will be required to provide environmental and social trainings to its staff, to ensure effective implementation of the ESMP. The training plan shall include a program for periodic training, to cover the subjects included in **Table 1.3**. Training should be carried out initially at induction of staff and repeated throughout the project.

Table 1.3 : Training Subjects for Inclusion in Contractors Training Plan

Training Subject	Target Audience
Awareness workshop regarding vector borne diseases and communicable diseases.	All staff
Handling, use & disposal of hazardous material	Construction workers involved in storage, handling, use & disposal of hazardous material.
Waste Management	All construction staff
Efficient & safe driving practices, including road & vehicle restrictions	Drivers & mobile plant operators
Pollution prevention: Best practice	All staff
Health & Safety: Safe way to work & hazard Awareness	All construction staff
Health & Safety: Safe use of plant & equipment	Operators of plant & equipment
Health & Safety: Working at height	Staff colony and regulator construction staff
Health & Safety: Use of PPE	All construction staff
Occupational Health and Safety	To all persons entering the construction site
Emergency procedures and evacuation	All staff
Spill clean-up training	Contractor's spill management staff
Fire fighting	All staff
Site inductions, including requirements under the Environmental Management Plans	All staff

1.9 AUDITS AND ANNUAL REVIEW OF ESMP

Internal environmental audits will be held with an objective to review the effectiveness of environmental management of the project. ESSU will carry out annual review of the appropriateness and adequacy of ESMP in the light of its own monitoring and supervision as well as on the basis of the third party monitoring and audits. ESSU will revise the EMP in case substantial gaps and shortcomings are identified in these plans.

External third party environmental audits will be held with an objective to review the effectiveness of environmental and social management of the project independently. It is proposed that third party carry out these audits on yearly basis. These audits would be used to re-examine the continued appropriateness of the ESMP and to provide advice on any updates required.

1.10 REPORTING

The Contractor will prepare monthly reports covering various aspects of the ESMP implementation including compliance and effects monitoring, capacity building, and grievance redressal during project implementation. MEC will prepare quarterly, biannual and annual reports during construction period. List of reports to be prepared during implementation and operation stages are presented in **Table 1.4.**

Table 1.4: Reporting During Implementation and Operation Stages

Report	Contents	Prepared by	Distribution
Monthly Progress Report for ESMP Compliance	Non-Compliances observed on sites and actions required	Contractor	ESSU (SMTA), CSDC, MEC,
Monthly Progress Report for ESMP Compliance	Actions taken on site in response to ESSU monthly report Project progress and works to be undertaken in the coming three months Details of training delivered Details of accidents reported and actions taken	Contractor	SMTA, CSDC, MEC, Sindh EPA
Quarterly Progress Report for ESMP Compliance	Quarterly review on implementation of ESMP including compliance and monitoring, capacity building, and grievance	CSDC	MEC, ESSU SMTA, World Bank, Sindh EPA.
Biannual Progress Report for ESMP Compliance	Biannual reporting for implementation of ESMP, environmental performance and occupational health and safety, including work hours, number of lost-time accidents/incidents, serious injuries and fatalities, amount of lost time, root cause investigations, etc. There should also be some incident reporting requirements, such as for major spills, fatalities,	CSDC	MEC, ESSU SMTA, World Bank, Sindh EPA
Annual Report for ESMP Compliance	Results of effects monitoring Independent review of environmental and social performance on site Recommended actions required by all parties	CSDC	ESSU SMTA, MEC, World Bank, Sindh EPA,

1.11 COST FOR IMPLEMENTATION OF ESMP

Cost for Testing of Ambient Air, Noise, Water

Testing and analysis for ambient air, noise and ground and surface water will be undertaken during pre-construction and construction to ensure the effectiveness of the proposed mitigation measures. Certain environmental parameters will be selected and quantitative analysis will be carried out. The results of analysis will be compared with the guidelines; standards and pre-project conditions to investigate whether the ESMP and its implementation are effective for the mitigation of impacts or not. Parameters to be analyzed during pre- construction, construction and operation phase of the project and responsibilities for monitoring and reporting have been discussed in the **Table 1.5.**

Table 1.5: Environmental Monitoring and Testing Cost Estimate

Sr. No.	Parameter	Mechanism	Frequency	Quantity	Remarks
A	**Pre- Construction Phase**				
1	Surface Water / Wastewater	Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring.	Once	01	One-time monitoring shall be carried out before the construction commencement.
2	Drinking Water / Ground Water	Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring.	Once	02	
3	Noise Levels	dBA Leq. as per SEQS 2014	Once	02	
4	Ambient Air Monitoring	Monitoring of CO, CO_2, SOx, NO_x, HC and $PM_{2.5}$ PM_{10} by EPA approved Laboratory	Once	02	
B	**Construction Phase (36 Months)**				
1	Surface Water / Wastewater	Discrete grab sampling and laboratory testing of water samples by EPA approved Laboratory for monitoring.	Quarterly	01	Quarterly monitoring cost for the one-year construction period and will be updated each year based on latest rates during construction timeline of the proposed Project.
2	Drinking Water/ Ground Water	Discrete grab sampling and laboratory testing of	Quarterly	02	

Sr. No.	Parameter	Mechanism	Frequency	Quantity	Remarks
		water samples by EPA approved Laboratory for monitoring.			
3	Noise Levels	dBA Leq. as per SEQS 2014	Quarterly	02	
3	Ambient Air Monitoring	Monitoring of CO, CO_2, SOx, NO_x, HC and $PM_{2.5}$ PM_{10} by EPA approved Laboratory	Quarterly	02	

1.12 TREE PLANTATION PLAN

The basic purpose of afforestation/plantation of suitable species in the project area is to reduce the risk been made due to cutting of trees for the proposed project and to enhance green cover and improve the overall environment of the area. Afforestation will not only reduce the risk been made but will also increase the carrying capacity of the area regarding many positive aspects.

Plantation will be done after the removal of trees during the construction work immediately. Plantation of indigenous trees species is highly important to maintain the biodiversity and ecological balance. It is also important to prevent global warming, soil erosion and pollution. Afforestation purifies the environment and helps in reducing the carbon dioxide level. The afforestation activity will further help in enhancing the socio-economic condition of the area and project sustainability. Total Number of 200 pots shall be provided as an environmental enhancement measure.

Note: *The above rates and calculations are approximate and tentative which shall be updated according to the standard rates of concerned Forest Departments/Implementing Agency, during implantation stage.*

1.13 COST FOR TRAINING AND CAPACITY BUILDING/STRENGTHENING

In order to ensure that the ESMP provisions are implemented efficiently and effectively, training and capacity building and strengthening are required. Therefore, based on the assessment of the institutional capacities that will be involved in the implementation of the ESMP, the following broad areas of capacity building/strengthening have been identified and recommended for the SMTA for effective implementation of the ESMP. Table 1.6 shows various trainings for implementation. All trainings are subjected to the prior approval and consent of the client.Table 1.6: Institutional Training for Implementation

Training Activity	Participants	Type of Training	Content	Scheduling
Construction Phase (02 years)				
Environment code of practices and ESHGS of WB	Contractor Staff	Presentation	Awareness; and Applicability of environmental code of practices	Biannually
Awareness workshop regarding Covid-19 and other vector borne diseases	Contractor Staff	Presentation	Risk, Prevention and available treatment	Biannually
Pollution prevention practices	Contractor Staff	Lecture	Awareness and importance of Practices to be adopted for pollution preventions	Biannually
Sensitivity to local culture	Contractor Staff	Lecture	Awareness of local culture and practices	Biannually

Awareness on vector borne diseases	Contractor Staff	Presentation	Risk, Prevention and available treatment	Biannually
Driver safety	Contractor Staff	Lecture	Risks, safe practices and responding to accidents	Biannually
Waste Management	Contractor Staff	Lecture	Awareness associated with waste Storage, collection and safe disposal	Biannually
Emergency Response	Contractor Staff	Workshop	Potential natural and other hazard/emergencies and dealing with emergency to minimize damage	Biannually
Ecological Conservation	Contractor Staff	Lecture	Awareness on regulations wild life and forest and penalties against violation of laws. Importance of protection of endangered species	Biannually
EPA Regulation	Managerial Staff of Contractor	Lecture	Awareness on EPA rules, guidelines, regulation and standards for satisfactory compliance	Biannually
World Bank Safeguard policies	Managerial Staff of Contractor	Lecture	Awareness on WB operational policies and best practices on environment and social issue	Biannually
Resettlement Related Issues	Contractor	Lecture	Awareness on ESS-5. Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	Biannually
Labour Management Procedures	Contractor Staff	Lecture	Awareness on World Bank ESS-2, Labour and working conditions and HIV/STDs	Biannually
Community/ occupational health and safety	Contractor Staff	Lecture	Awareness on World Bank ESS-4, Community health and safety	Biannually

Gender Aspects	Contractor Staff	Lecture	Awareness on gender inequalities/GBV	Biannually

1.14 COST FOR PERSONAL PROTECTIVE EQUIPMENT (PPE)

The cost required to effectively implement the mitigation measures is important for the sustainability of the project and shall be considered in environmental management (**Table 1.7**).

Table 1.7: Environmental Management Cost

Items	Unit	Cost
Personal Protective Equipment cost	Rs.	
Environmental Monitoring and Testing Cost	Rs.	
Tree Plantation Cost	Rs.	
Institutional Training Cost	Rs.	
Sub Total	**Rs.**	
Total	**Rs.**	

Volume 5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

Request For Proposal Documents
Works (Design and Build)

Main Contents

VOLUME (1): **Instructions to Proposers (ITP) &**
Proposal Data Sheet (PDS), Proposal Forms / Schedules,
Conditions of Contract, Contract Forms / Schedules

Part 1 - Request for Proposal Procedures
Section I Instructions to Proposers (ITP)
Section II Proposal Data Sheet (PDS)
Section III Evaluation and Qualification Criteria
Section IV Proposal Forms
Section V Eligible Countries
Section VI Fraud and Corruption

Part 2 - Employer's Requirements
Section VII Employer's Requirements

Part 3 - Conditions of Contract and Contract Forms
Section VIII General Conditions (GC)
Section IX Particular Conditions (PC)
Section X Contract Forms

VOLUME (2):

Part (A) Employer's Requirements
1) Introduction
2) General Overview of the Project
3) Design Intent
4) Design Responsibility
5) Interface Management
6) Design Stages and Deliverables
7) Basis of Design

Part (B) Specifications (1 of 2)
Division 01 - General Requirements

Part (B) Specifications (2 of 2)
Division 02 - Site Construction
Division 03 - Concrete
Division 07 - Thermal and Moisture Protection
Division 26 - Electrical
Division 31 - Earthwork
Division 32 - Exterior Improvements
Division 33 - Utilities
Division 34 - Transportation

VOLUME (3): Basis of Pricing & Pricing Schedules

Basis of Pricing

Pricing Preambles
1 Design & Special Works
2 Bridge Works
3 Roadworks
4 Electrical Works
5 Utilities

Pricing Schedules

Summary
1 General and Particular Conditions of Contract
2 General Requirements
3 Design & Special Works
4 Bridge Works
5 Roadworks
6 Electrical Works
7 Utilities

VOLUME (4): Drawings

01- Roads
02- Bridge
04- Utilities

VOLUME (5): Technical Documents "For Information":

5A - Geotechnical Investigation
5B - Hydrology and Hydraulics Study Report
5C - Environmental and Social Management Plan
5D - Structure Condition Survey – Existing Jam Sadiq Bridge Assessment & Rehabilitation Report

KARACHI MOBILITY PROJECT

Yellow BRT Corridor

STRUCTURE CONDITION SURVEY - EXISTING JAM SADIQ BRIDGE ASSESSMENT & REHABILITATION REPORT

P21161-4309 January 2022

CONTENTS

1. INTRODUCTION **1**
2. LOCATION MAP **2**
3. TECHNICAL ASPECTS CONSIDERED IN INSPECTION **3**
3.1 DESCRIPTION OF BRIDGE **3**
3.2 SPECIAL FEATURES **3**
4. BRIDGE INSPECTION RESULTS **4**
4.1 INSPECTION METHODOLOGY **4**
4.2 BRIDGE INVENTORY DATA **5**
4.3 BRIDGE INSPECTION RESULTS **7**
4.3.1 SPANS 9, 10 INSPECTIONS 7
4.3.2 SPANS 12, 13, 15, 16, 17 INSPECTIONS 14
4.3.3 SPANS 19 TO 25 & 28-30 INSPECTIONS 21
4.3.4 SPANS 11, 14 AND 31-37 INSPECTIONS 32
4.3.5 SPANS 1 -8 INSPECTIONS 41
4.3.6 BRIDGE ARTICULATION AND ACCESSORIES 44
4.3.7 INSPECTION MAIN FINDINGS 50
5. TESTING PLAN & RESULTS **51**
5.1 TESTING CAMPAIGN **51**
5.2 TEST PERFORMANCE & RESULTS **52**
5.2.1 CORE TESTS - ASTM C42, ASTM C39 52
5.2.2 REBOUND HAMMER TESTS ASTM C805 59
5.2.3 CUT & PULL OUT CAPO TESTS 59
5.2.4 CARBONATION TESTS - BS EN 14630 60
5.2.5 CHEMICAL ANALYSIS TESTS, CHLORIDES, SULPHATES, CEMENT CONTENT BS1881-124 61
5.2.6 POROSITY & ABSORPTION RATIO ASTM C642 62
5.2.7 REINFORCEMENT SCANNING 62
5.3 TESTING MAIN FINDINGS **63**
6. OVERALL ASSESSMENT OF THE BRIDGE **64**
6.1 HEALTH INDEX RATING **64**

6.2 DEGRADATION RATE **64**
6.3 MIDDLE SPANS SETTLEMENT **69**
6.4 CAPACITY CHECKS **70**
7. PROPOSED REHABILITATION & PROTOCOL **71**
7.1 MAIN REHABILITATION SCHEME **71**
7.2 FEASIBILITY **71**
8. CONCLUSION & RECOMMENDATIONS **73**
9. APPENDIX A - CONDITION RATING RESULTS & REHABILITATION **74**
10. APPENDIX B – TEST CAMPAIGN
11. APPENDIX C - TEST RESULTS

LIST OF FIGURES

Figure 2.1 Existing Jam Sadiq Bridge Location Map 2

Figure 3.1 Cross Section of the Existing Bridge Main Spans Surveyed from Site 3

Figure 4.1 Part of Inspection Tools Used 4

Figure 4.2 Example AASHTO Defect Condition State Determination Table – AASHTO MBEI 2015 5

Figure 4.3 General View of Existing Jam Sadiq Bridge 7

Figure 4.4 Condition of Corrosion, Spalling and Cracks 9

Figure 4.5 Severe Spalling, Corrosion and De-bonding at Diaphragm 9

Figure 4.6 Severely Spalled and Cracked Deck Slab Especially at Drainage Opening 10

Figure 4.7 Slab Reinforcement Corrosion Marks on Soffit 11

Figure 4.8 Major Corrosion Section Loss and Spall in Pier Cap Grid Axis 10 12

Figure 4.9 Pier Major Corrosion and Spalls at Grid axis 10 with High Crack Width After 2015 Repair 13

Figure 4.10 Wide Spall Cracks and Delamination on Pier Caps 12, 15 15

Figure 4.11 Spalls and Cracks at Critical Load Bearing Zone of Pier Cap 16 16

Figure 4.12 Corrosion Cracks and Spalling on Grid Axis 12 after 2015 Repair & Zero Cover 17

Figure 4.13 Severe Spalls and Cracks in Original Piers and Jackets on Grid Axis 17 18

Figure 4.14 Eccentricity and Lack of Plumbness in Pier Jacket Grid Axis 16 19

Figure 4.15 Spall in the under Load Region of Pier Cap 15 **Figure 4.16** Almost Zero Girder Cover Span 17 20

Figure 4.17 Spalls at Critical Load Zone of Pier Cap 20 23

Figure 4.18 Severe Deterioration in Pier Cap 22 23

Figure 4.19 Critical Zone Spalls and Cracks Piers, Pier Cap and Girder Lack of Cover at Axis 19 24

Figure 4.20 Spalls at Critical Load Zone of Pier Cap 23 25

Figure 4.21 Poor Quality of Original Pier Concrete Grid Axis 23 25

Figure 4.22 Complete Lack of Cover and Spalling at Pier Grid Axis 23 26

Figure 4.23 Lack of Cover and Possible Load Spall at Pier Grid Axis 25 26

Figure 4.24 Wide Crack and Spall in both the Original Column and the Jacket at the Same Location,

at Axis 25 27

Figure 4.25 Critical Crack and Spalling at Load Region of Pier Grid Axis 24 28

Figure 4.26 Lack of Cover Pier Grid Axis 28 28

Figure 4.27 Critical Crack and Spalling at Load Region of Pier Grid Axis 30 29

Figure 4.28 Lack of Cover on Pier Cap and Girder and Loss of Bond at Grid Axis 25 29

Figure 4.29 Lack of Cover in Girders Span 28 30

Figure 4.30 Critical Difference in Level between Side Spans and Mid Spans and between 2019, 2021 Surveys 31

Figure 4.31 Cracks and Spalls, Pier Cap of Column Grid Axis 11 34

Figure 4.32 Critical Deterioration and Lack of Cover at Pier Cap Grid Axis 13 35

Figure 4.33 Critical Slab Defect Locations on Span 11 in Need of Fast Track Intervention 36

Figure 4.34 Critical Lack of Cover in Girders Span 14 36

Figure 4.35 Spall in Concrete Pier on Grid Axis 34 37

Figure 4.36 Severe Honeycombing in Deck Slab Span 37 37

Figure 4.37 Spread Severe Corrosion Span 33 38

Figure 4.38 Spalled and Cracked Pier and Cap Axis 32 38

Figure 4.39 Spalled and Cracked Pier and Cap Axis 31 39

Figure 4.40 Spalled and Cracked Deck Slab Span 32 39

Figure 4.41 Severe Corrosion and Deck Spalling Span 32 40

Figure 4.42 Severe Corrosion and Deck Spalling Span 35 40

Figure 4.43 Spread Corrosion in Deck Slab Span 36 41

Figure 4.44 Spread Corrosion in Deck Slab Span 36 41

Figure 4.45 Pier Cap 2 Severe Corrosion Affecting Anchorage Strength 43

Figure 4.46 Deck Slabs Severe Spalls 43

Figure 4.47 Typical Condition of Bearing with Tears, Deterioration and Split 45

Figure 4.48 Typical Condition of Bearing with Tears, Deterioration and Split 45

Figure 4.49 Partial Loss of Bearing Seating and Bearing Deterioration at Axes 15 and 10 46

Figure 4.50 Typical Deterioration State of the Neoprene 46

Figure 4.51 Debris Totally Blocking Bearing Movement 47

Figure 4.52 Bearing Deterioration, Splitting and Tearing 47

Figure 4.53 Typical Condition of the Expansion Joint and Drainage 48

Figure 4.54 Typical Condition of the Expansion Joints 48

Figure 4.55 Typical Condition of the Sidewalk and Barrier 49

Figure 5.1 Core Extraction from Pier Cap 52

Figure 5.2 Application of Non-Shrink Grout to extracted core locations 53

Figure 5.3 Core Compression Testing Example 54

Figure 5.4 Core Failure Examples, a) Pier #6 Core, b) Pier Cap #9 Core & c) Pier #36 Core 54

Figure 5.5 Rebound Hammer Testing 59

Figure 5.6 CAPO Test Method 60

Figure 6.1 Evaluation of degradation trend from Condition Based Degradation Matrices 65

Figure 6.2 ACI Life 365 for Chloride Effect on Service Life Estimation 68

Figure 6.3 Critical Difference in Top of Deck Levels from 2019, 2021Topo- Surveys 70

LIST OF TABLES

Table 4.1 Bridge Inventory Data 6
Table 5.1 Piers Compressive strength testing Results 55
Table 5.2 Pier Caps Compressive strength testing Results 57
Table 5.3 Deck slab and Girders Compressive strength testing Results 58
Table 5.4 Depth of Carbonation for different Bridge Elements 60
Table 5.5 Chloride & Sulfate Concentrations 61
Table 5.6 Void Ratio Test Results 62
Table 5.7 Concrete Clear Cover values obtained from scanning 62
Table 6.1 Chloride Diffusion & Estimated Remaining Life 66

1. INTRODUCTION

This report is submitted to Sindh Mass Transit Authority “SMTA” to provide the base structural assessment of the existing Jam Sadiq Bridge in Karachi based on the available results of inspection and testing conducted during the month of October 2021. There was no design, as-built nor repair project documents or drawings available except for 6 layouts of previous deck slab repair.

The inspection and evaluation of the inspection results are conducted according to international standards namely the AASHTO Manual of Bridge Element Inspection MBEI 2015. Field testing was conducted by an external test provider (M&F Engineering). A brief proposal of the required rehabilitation is also provided in the report.

2. LOCATION MAP

The existing bridge is located in the southern part of the city of Karachi as shown in Figure 2.1.

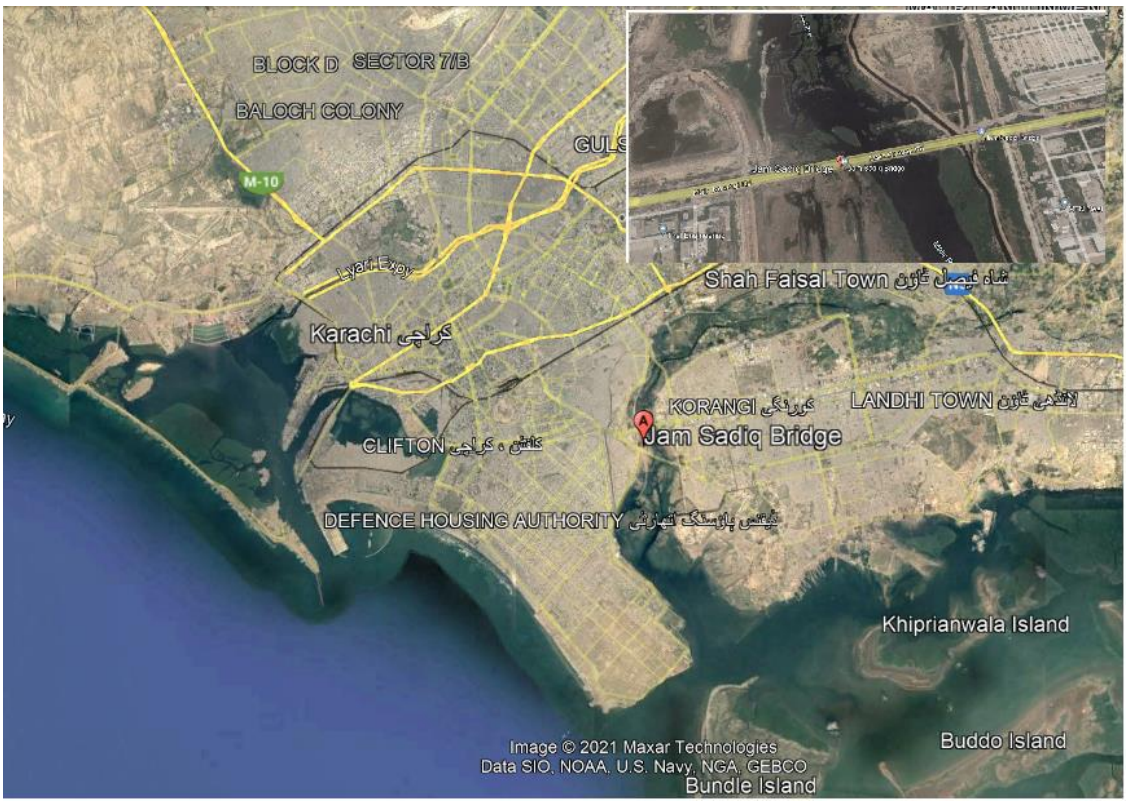


Figure 2.1 *Existing Jam Sadiq Bridge Location Map*

3. TECHNICAL ASPECTS CONSIDERED IN INSPECTION

3.1 DESCRIPTION OF THE BRIDGE

Jam Sadiq Bridge was constructed in 1992 to cross the Malir River wadi in the city of Karachi. The river is being used currently and during the past several years as a discharge channel for domestic and industrial waste. The bridge is composed of 38 concrete slab and multiple girder spans. The spans are resting on pier bents through elastomeric bearings sitting over pier head transoms (Refer to Figure 3.1 for typical 32m long span bridge section). The round shaft piers had been repaired in 2015 by jacketing and are supported by foundations underground. The deck slabs had also been repaired by thickness augmentation in one part of the spans and by complete replacement on the other part. No design data is available to the day of preparation of this report about the existing structure nor its full repairs.

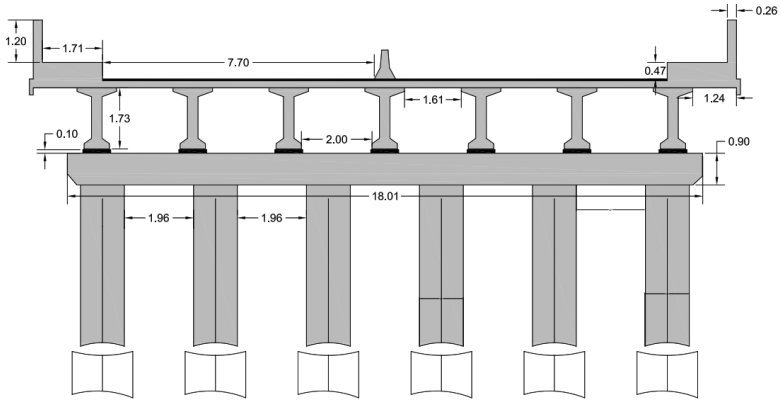


Figure 3.1 *Cross Section of the Existing Bridge Main Spans Surveyed from Site*

3.2 SPECIAL FEATURES

The Bridge crosses Malir River which is used as an untreated human and industrial waste channel. The channel undergoes cycles of partial flooding and drying according to flood season. This affects the structural elements and materials in the waterway zones.

4. BRIDGE INSPECTION RESULTS

4.1 INSPECTION METHODOLOGY

As the bridge in this region is located in a polluted water stream and vegetation area (see 3.2), and given existing obstacles and partial security restrictions, the findings used for assessment of the overall condition are from the accessible parts of the structure.

Several tools were used during the inspection including steel detectors, wind speed and thermal sensors, laser distance meters, endoscope special looped camera to monitor inaccessible bearing areas in addition to several hand tools as shown in Figure 4.1.

The bridge spans and main elements are numbered in ascending sequential order from KPT side to Korangi side. The span number is the number of the grid axis at the end of the span. The line of piers or pier bent number is the number of the grid axis it is located on. A surveyed bridge inventory data was collected.

Accessible elements were hands-on inspected, and their defects were documented on site sketches and with digital photography and videos. It is noteworthy that such hands-on inspection was not free from dangers from the wilderness threats.

Figure 4.1 *Part of Inspection Tools Used*

Specially designed inspection templates were also used to assess the spread and severity of possible defects in each element according to the criteria of AASHTO MBEI 2013/2015. The AASHTO defects are coded using the AASHTO defect numbers and the extent of each defect is determined according to the preset AASHTO level criteria as exemplary shown in the table in Figure 4.2. The full details and list of the AASHTO defects condition state criteria tables are found in the referenced AASHTO MBEI.

Defect	Example AASHTO Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Delamination / spall / patched area (1080)	None.	Delaminated Spall 1 in. Or less deep or 6in diameter. Patched area that is sound.	Spall greater than 1in. Diameter, Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determinate the effect on strength of serviceability of the element or bridge; or a structural review has been completed and the defects impact strength or serviceability of the element of bridge.
Exposed rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescent / rust staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy built-up with rust staining.	
Cracking (RC and other) (1130)	Width less than 0.012 In. Or spacing greater than 3.0 Ft.	Width 0.012-0.05In. Or spacing of 1.0-3.0Ft.	Width greater than 0.05In. Or spacing of less than 1Ft.	
Abrasion / wear (psc/rc) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	

Figure 4.2 *Example AASHTO Defect Condition State Determination Table – AASHTO MBEI 2015*

4.2 BRIDGE INVENTORY DATA

In the absence of full as-built and design drawings or data, the inspection team attempted to collect as-existing data from site as accessibility permits. The following Table 4.1 gives details about the main bridge inventory data collected from site.

Table 4.1 *Bridge Inventory Data*

Location Data				Remarks
Name of Bridge	Jam Sadiq	Road -KM	Urban	Crosses Malir Waste Water Channel
Province	Korangi	GIS Location	24o 49' 56.23" N 67o 05' 18.83 " E	
Material of Construction	RC	Approx Age	>10 years	
Geometric Data				
Length (m) / Skewness	985	Width of Roadway (m)	2x7.7	
Vertical Clearance (m)	4-10	Hrz. Clearance (m)	N/A	
Structural System Data				
No of Spans	38	Span Configuration	Simple Spans 18, 32m	
Construction Type	Cast in-situ			
Type of Superstructure	Concrete deck slab on girders			
Type of Abutment	Concrete Abutment			No data on foundation
Type of Piers	Round Column Piers and RC pier caps			
Type of Exp Joints	Sealed Plate Joint			
Type of Bearings	Elastomeric Bearings			
Wearing Surface & Utilities Data				
W.S / Pavement	Asphalt	Signage/Marking	No	
Bridge Lighting	In median	Waterway	Yes	
Deck Drainage	Blocked - openings	Railing	RC	

* the given data includes site approximation

Figure 4.3 *General View of Existing Jam Sadiq Bridge*

4.3 BRIDGE INSPECTION RESULTS

The following tables present the results of the inspections performed on the parts of the bridge. The defect condition state coding as explained in the methodology in clause 4.1 starting with the most critical spans, followed the AASHTO four condition state criteria, “GOOD”, “FAIR”, “POOR” and “SEVERE”. Each condition state is represented by a colour code in which “GOOD” is given a green colour label, “FAIR” is given a yellow colour label, “POOR” is given a brown orange colour label and “SEVERE” is given a red colour label. From these levels of condition states representing levels of health of an element, the health indices are obtained in section 6. The distribution of defect severity on spans is presented on the elevation in Appendix (A) per the numbering described in 4.1.

4.3.1 SPANS 9, 10 INSPECTIONS

The defects commonly found in these spans are described below.

- Inspection of Superstructure Girders,

AASHTO Cond.

State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Several large spalls with deteriorated and corroded steel reinforcement near the edge seating of the girders around grid axis 9 for these spans. One observed cracked girder end. Span 9 girders show less defects.			
Cracking & Damage (1130) , (7000)	Observed cracked girder end at grid axis 9 span 10 side.			

- Inspection of Superstructure Deck Slab:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Leakage apparent efflorescence on the underside indicating high permeability of the slab. Steel reinforcement reflection marks on the soffit of the slab indicating internal corrosion. Severe cracking, spalling and disintegration around the drainage pipe opening. Span 9 show less defects but defect progression expected.			
Cracking & Damage (1130), (7000)	Limited cracking			

- Inspection of Piers:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900), **Settlement, (4000)**	No Major Observation			
Crack, Spall, Defects (1080), (1130).	Severe corrosion cracks and spalls after 2015 repair. Most of axis 9 piers/vertical elements are covered under artificial fill hindering their durability and causing severe corrosion.			

- **Additional Remarks**: Elements hidden on grid axis 9 are under a formed embankment

- Inspection of Pier Caps:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Crack, Spall, Defects (1080), (1130),	Severe corrosion crack and spalls after 2015 repair. Complete section loss of reinforcement and debonding and complete spalling encountered			

- **Additional Remarks**: Elements hidden on grid axis 9 under a formed embankment

Figures from 4.4 to 4.9 show example conditions of different elements of Spans 9 & 10.

Figure 4.4 *Condition of Corrosion, Spalling and Cracks*

Figure 4.5 *Severe Spalling, Corrosion and De-bonding at Diaphragm*

Figure 4.6 *Severely Spalled and Cracked Deck Slab Especially at Drainage Opening*

Figure 4.7 *Slab Reinforcement Corrosion Marks on Soffit*

Figure 4.8 *Major Corrosion Section Loss and Spall in Pier Cap Grid Axis 10*

Figure 4.9 *Pier Major Corrosion and Spalls at Grid axis 10 with High Crack Width After 2015 Repair*

4.3.2 SPANS 12, 13, 15, 16, 17 INSPECTIONS

The defects commonly found in these spans are described below.

- Inspection of Superstructure Girders,

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Localized corrosion. lack of cover depth observed in spans 13 and Spans 12, 15 show less defects.			
Cracking & Damage **(1130), (7000)**	No major crack detected from visual inspection			

- Inspection of Superstructure Deck Slab:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Some Leakage apparent efflorescence on the soffit. Typical localized corrosion deterioration and severe cracking, spalling and disintegration around the drainage pipe opening. Slabs of spans 13, 17 show more defects in poor condition.			
Cracking & Damage **(1130), (7000)**	Limited cracking			

- Inspection of Piers:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900) **Settlement, (4000)**	Clear visible eccentricity and loss of plumpness due to the construction of jacket on grid axis 16, pier lines 13, 15 are in poor condition.			
Crack, Spall, Defects (1080), (1130),	Severe corrosion crack and spalls after 2015 repair.			

- Inspection of Pier Caps:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Crack, Spall, Defects (1080), (1130),	Severe corrosion crack and spalls after 2015 repair. Complete separations and spalls as illustrated in the figures below. Transoms 13, 15 are in poor condition			

Figures from 4.10 to 4.16 show example conditions of different elements in spans 12, 13, 15, 16 & 17. Appendix A Provide distribution of the defect severity condition states over the spans.

Figure 4.10 *Wide Spall Cracks and Delamination on Pier Caps 12, 15*

Figure 4.11 *Spalls and Cracks at Critical Load Bearing Zone of Pier Cap 16*

Figure 4.12 *Corrosion Cracks and Spalling on Grid Axis 12 after 2015 Repair & Zero Cover*

Figure 4.13 *Severe Spalls and Cracks in Original Piers and Jackets on Grid Axis 17*

Figure 4.14 *Eccentricity and Lack of Plumbness in Pier Jacket Grid Axis 16*

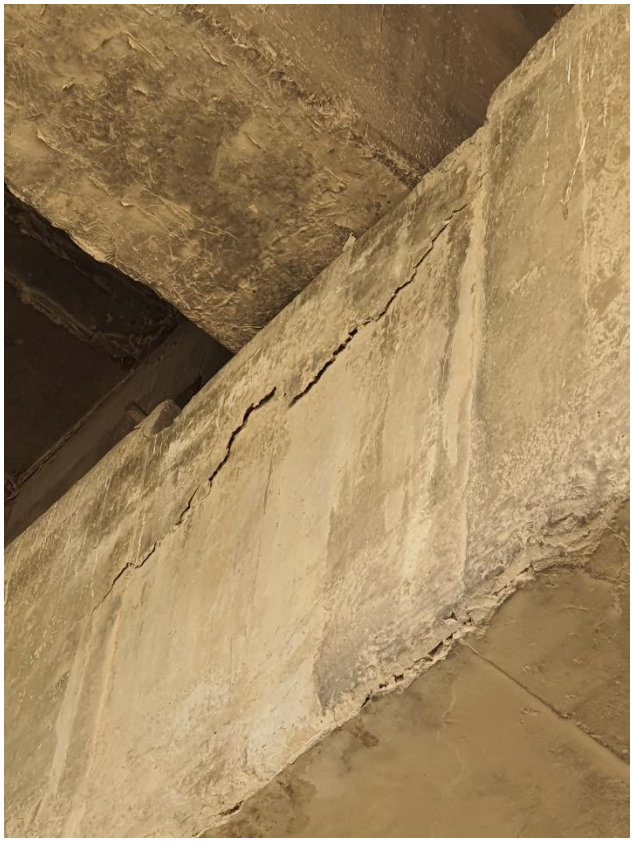


Figure 4.15 *Spall in the under Load Region of Pier Cap 15*

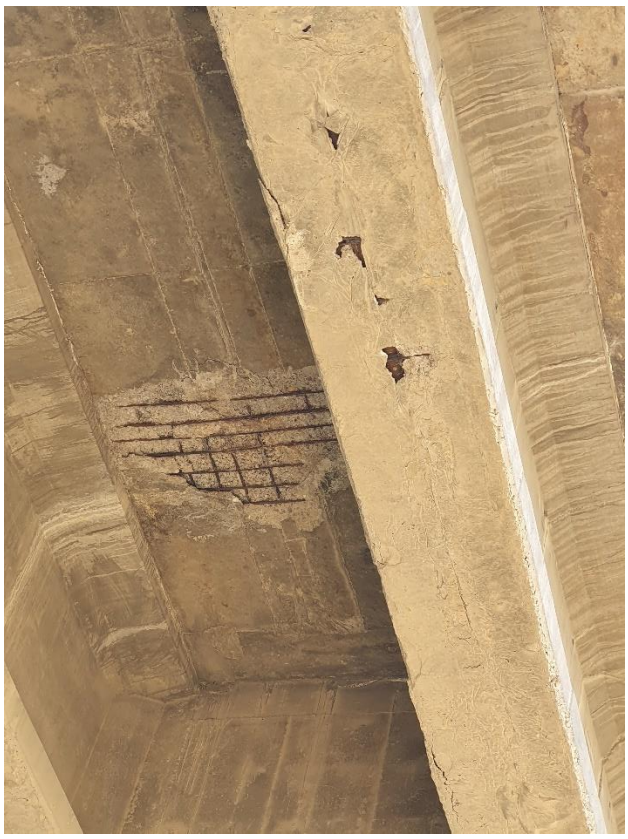


Figure 4.16 *Almost Zero Girder Cover Span 17*

4.3.3 SPANS 19 TO 25 & 27 TO 30 INSPECTIONS

The defects commonly found in these spans are described below. Spans 19-25 were inspected from one side closer than from the other due to partial restriction caused by the water stream and vegetations. The effect of the high chloride and high sulphate polluted water attack on durability of the concrete elements in these water stream spans, especially their embedded underground foundation is causing a severe environment attack and exposure condition.

- Inspection of Superstructure Girders,

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	No major defect. Lack of cover depth in spans 27-29 in which the condition state is poor.			
Cracking & Damage **(1130), (7000)**	No major crack detected from visual inspection			

- Inspection of Superstructure Deck Slab:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Leakage apparent efflorescence on the soffit. Typical severe corrosion and deterioration similar to other spans and severe cracking, spalling and disintegration around the drainage pipe opening.			
Cracking & Damage **(1130), (7000)**	Limited cracking			

- Inspection of Piers:

-

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900) **Settlement, (4000)**	No major defect observed by visual inspection			
Crack, Spall, Defects (1080), (1130),	Poor to severe with complete or severe lack of cover indicating imminent complete loss from corrosion attack. Severe complete cover spall in column critical section and dry zone indicating possible spall under load. Several new cracks in jacket reflection of original column cracks indicating the original corrosion and crack defect was not completely treated in previous repair. Pier lines 24, 30 show less defects but with expected progression.			

- Inspection of Pier Caps:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Crack, Spall, Defects (1080), (1130),	Severe corrosion crack and spalls after 2015 repair. Complete separations and spalls, as illustrated in the figures below. Pier caps at axes 21, 27, 28 have less defects. High surface void ratio observed			

Figures 4.17 to 4.29 show example conditions of different elements in spans 19 to 25 & 27-30.

Figure 4.17 *Spalls at Critical Load Zone of Pier Cap 20*

Figure 4.18 *Severe Deterioration in Pier Cap 22*

Figure 4.19 *Critical Zone Spalls and Cracks Piers, Pier Cap and Girder Lack of Cover at Axis 19*

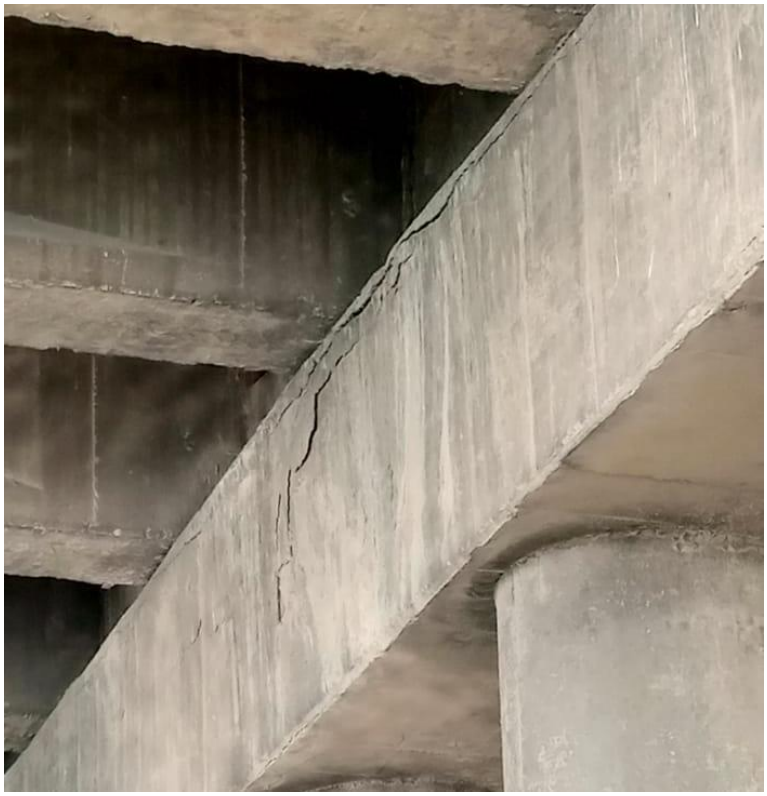


Figure 4.20 *Spalls at Critical Load Zone of Pier Cap 23*

Figure 4.21 *Poor Quality of Original Pier Concrete Grid Axis 23*

Figure 4.22 *Complete Lack of Cover and Spalling at Pier Grid Axis 23*

Figure 4.23 *Lack of Cover and Possible Load Spall at Pier Grid Axis 25*

Figure 4.24 *Wide Crack and Spall in both the Original Column and the Jacket at the Same Location, at Axis 25*

Figure 4.25 *Critical Crack and Spalling at Load Region of Pier Grid Axis 24*

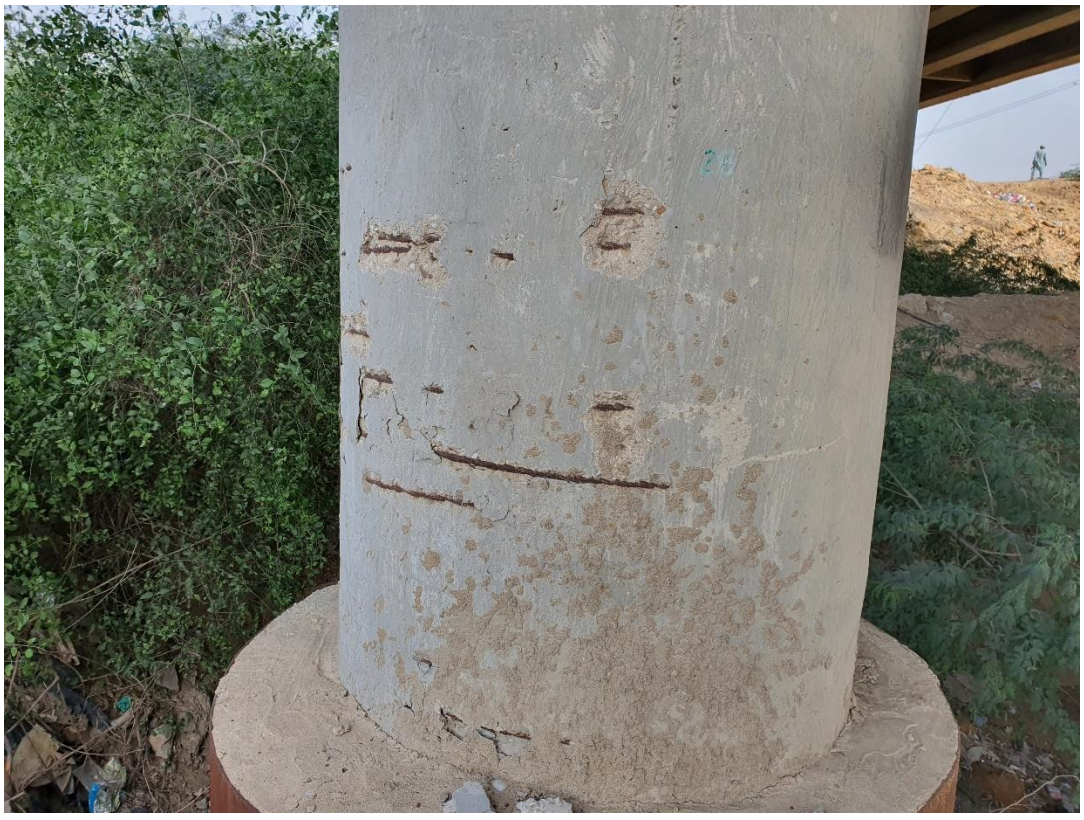


Figure 4.26 *Lack of Cover Pier Grid Axis 28*

Figure 4.27 *Critical Crack and Spalling at Load Region of Pier Grid Axis 30*

Figure 4.28 *Lack of Cover on Pier Cap and Girder and Loss of Bond at Grid Axis 25*

Figure 4.29 *Lack of Cover in Girders Span 28*

4.3.4 DECK PROFILE & PIER SETTLEMENT

From topo-survey results of 2021 and the limited data available from 2019 survey, a detection of downward movement (settlement) of the middle spans could be made. Linking the two surveys was done on assumptions described in Section 6.3. It was detected that the elevation of the deck at pier locations for the middle spans is up to 150mm lower than the highest deck elevation (KPT side). Furthermore, the middle spans' piers (19-26) have about 100mm lower level in 2021 than the values of 2019. This can indicate a very serious settlement movement in the waterway spans. This value of settlement is considered critical and attributed to a critical foundation condition requiring fast track action. In addition to their structural defects, this variation requires replacement of these spans. Figure 4.30 below shows this elevation differences.

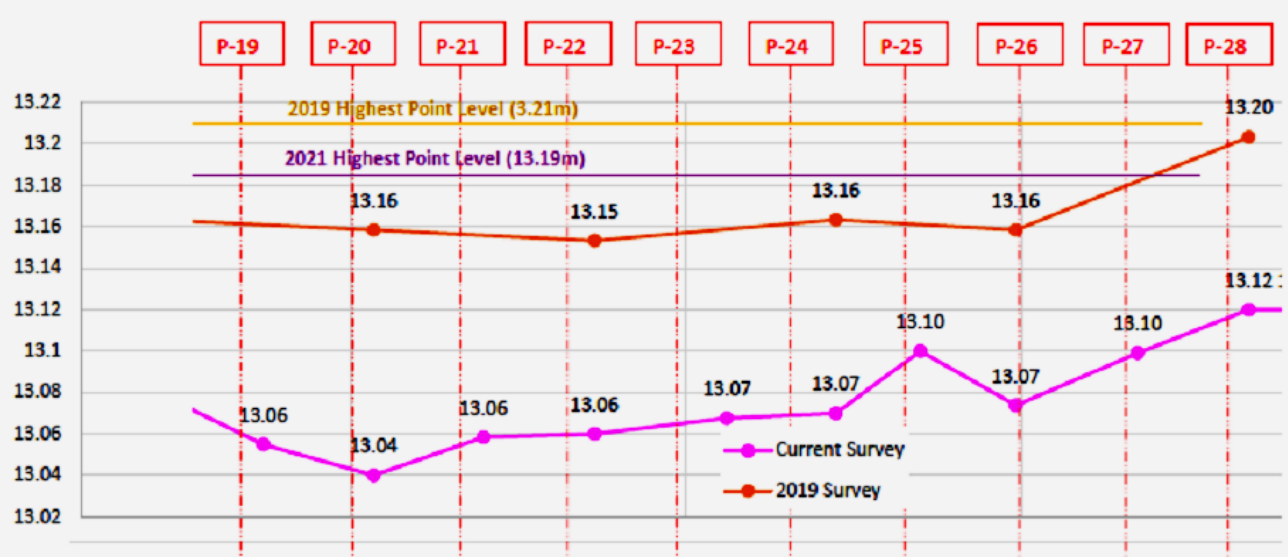


Figure 4.30 *Critical Difference in Level between Side Spans and Mid Spans and between 2019, 2021 Surveys*

4.3.5 SPANS 11, 14, 18, 26 AND 31 TO 37 INSPECTIONS

The defects commonly found in these spans are described below. The spans listed above have less severe condition states regarding the girders (span 38 was inaccessible for inspection), piers, and pier caps mostly in fair conditions. However, the deck slab condition for several of these spans is in poor to severe condition namely spans 11, 14, 31 to 35 & 37. Below in figures 4.31 to 4.44 are some example pictures of the deck slab deteriorations in these spans.

- Inspection of Superstructure Girders,

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	No major defect. Consistent lack of cover depth. Low cover and local defects are noticed in span 14			
Cracking & Damage (1130), (7000)	No major crack detected from visual inspection			

- Inspection of Superstructure Deck Slab:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Leakage apparent efflorescence on the soffit. Typical spread corrosion and deterioration and severe cracking, spalling and disintegration. Cases range from poor to local severe as shown in the below pictures. Segregation honeycombing and high surface void ratios observed.			
Cracking & Damage (1130), (7000)	Limited cracking			

- Inspection of Piers:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900) Settlement, (4000)	No major defect observed by visual inspection.			
Crack, Spall, Defects (1080), (1130)	Good to Fair in most piers as shown below.			

Inspection of Pier Caps:

AASHTO Cond. State / Defect	**Good**	**Fair**	**Poor**	**Severe**
Crack, Spall, Defects (1080), (1130),	Fair to poor condition of corrosion of some of the pier caps as illustrated below. Transoms 26, 34, 37 are in fair condition and 35, 36 are with less defects.			

Figures 4.31 to 4.44 show example conditions of different elements in spans 11, 14, 18, 26 and 31-37.

Figure 4.31 *Cracks and Spalls, Pier Cap of Column Grid Axis 11*

Figure 4.32 *Critical Deterioration and Lack of Cover at Pier Cap Grid Axis 13*

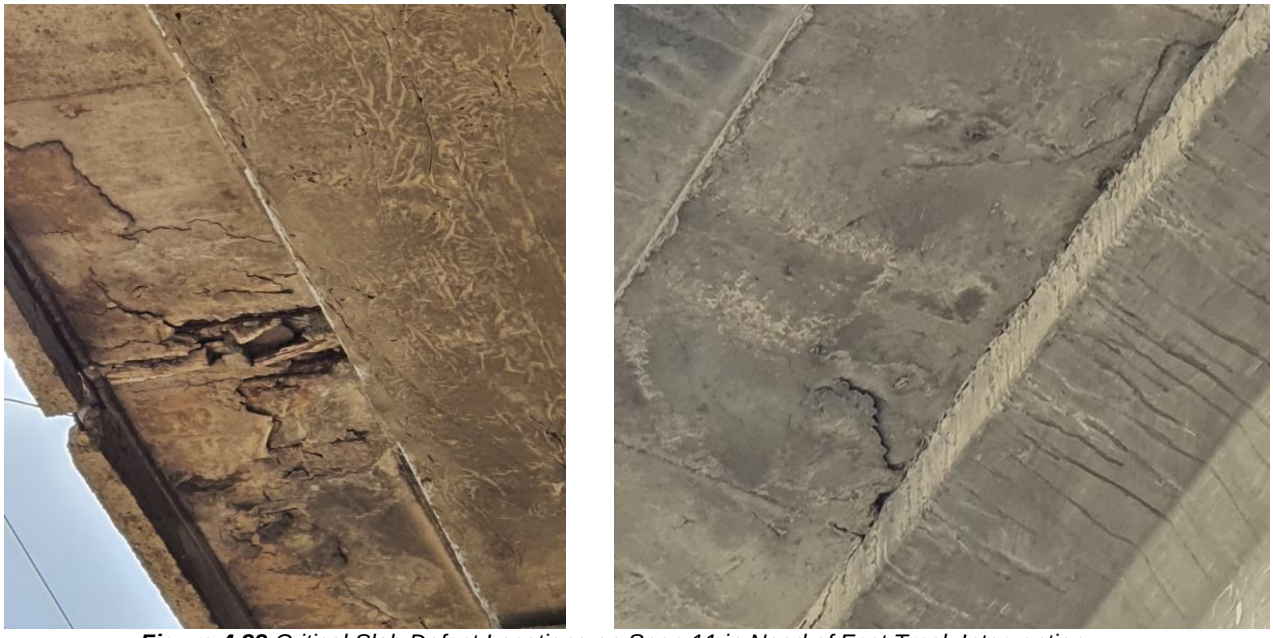


Figure 4.33 *Critical Slab Defect Locations on Span 11 in Need of Fast Track Intervention*

Figure 4.34 *Critical Lack of Cover in Girders Span 14*

Figure 4.35 *Spall in Concrete Pier on Grid Axis 34*

Figure 4.36 *Severe Honeycombing in Deck Slab Span 37*

Figure 4.37 *Spread Severe Corrosion Span 33*

Figure 4.38 *Spalled and Cracked Pier and Cap Axis 32*

Figure 4.39 *Spalled and Cracked Pier and Cap Axis 31*

Figure 4.40 *Spalled and Cracked Deck Slab Span 32*

Figure 4.41 *Severe Corrosion and Deck Spalling Span 32*

Figure 4.42 *Severe Corrosion and Deck Spalling Span 35*

Figure 4.43 *Spread Corrosion in Deck Slab Span 36*

Figure 4.44 *Spread Corrosion in Deck Slab Span 36*

4.3.6 SPANS 1 - 8 INSPECTIONS

The defects commonly found in these spans are described below.

- Inspection of Superstructure Girders:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	No major defect.			
Cracking & Damage (1130), (7000)	No major crack detected from visual inspection			

- Inspection of Superstructure Deck Slab:

AASHTO Cond. State / Defect	Good AASHT	Fair	Poor	Severe
Corrosion, Spall/Delamination, Efflorescence (1090), (1080), (1120)	Leakage apparent spalls ranging around 2-3m sizes with efflorescence on the soffit.			
Cracking & Damage (1130), (7000)	Limited cracking			

- Inspection of Piers:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900) Settlement, (4000)	No major defect observed by visual inspection.			
Crack, Spall, Defects (1080), (1130)	Fair in most piers.			

- Inspection of Pier Caps:

Figures 4.45 and 4.46 show example conditions of different elements in spans 1- 8. These spans were partially inspected due to restricted access to military zone.

Defect	Good	Fair	Poor	Severe
Distortion, tilt (1900) Settlement, (4000)	No major defect observed by visual inspection			
Crack, Spall, Defects (1080), (1130),	Fair in most piers.			

Figure 4.45 *Pier Cap 2 Severe Corrosion Affecting Anchorage Strength*

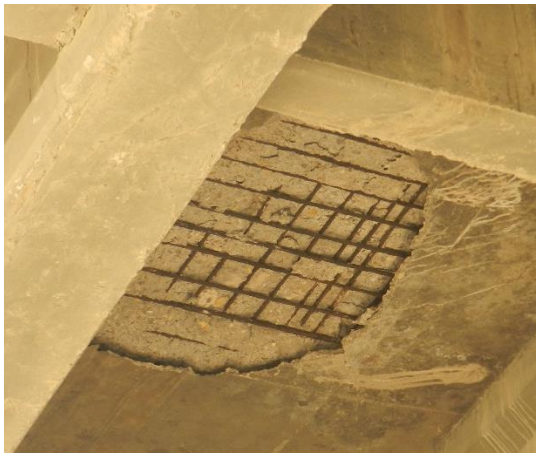


Figure 4.46 *Deck Slabs Severe Spalls*

4.3.7 BRIDGE ARTICULATION AND ACCESSORIES

Bearings,

The bridge is supported over the pier caps though elastomeric bearings at each main girder. The condition of bearings is similar among the spans and ranges from poor to severe. Most of the bearings have similar conditions of deterioration as presented in the below table and Figures from 4.47 to 4.52.

- Inspection of Bearings:

AASHTO Cond. State / Defect	Good	Fair	Poor	Severe
Type, Alignment, Movement, geom., (2210, 20, 40)	Limited alignment defects encountered. Movement is restricted by severe debris accumulations.			
Corrosion, tearing, bulging, damage (1000, 2000, 2230)	Elastomeric material is deteriorated and contains several tearing.			
Connecting Elements (1020)	Several bearing zone elements are severely affected by corrosion, spalled and deteriorated.			

Expansion Joints, Drainage and Barriers

The expansion joint plates are in fair condition; however the neoprene gland is deteriorated and poor resistance for storm water leakage is observed. Drainage system is not effective and is fully blocked with dust accumulations, which affects the bridge structure especially at joints and deck slabs. The pavement and barriers are in poor condition as demonstrated in the below table and Figures from 4.53 to 4.55.

Defect	Good	Fair	Poor	Severe
Expansion Joints	The type of expansion joint used proved inefficiency for storm water leakage resistance. Debris block all expansion joints and the glands are deteriorated. The steel plates are in acceptable condition.			
Pavement	Affected by severe defects including rutting and shoving, large potholes and wear of the top layer in several locations. Detailed condition is in pavement report.			
Barriers	Several spalls, corrosion, lack of cover, poor concrete quality			
Deck Drainage	Accumulation of the debris at the expansion joint location indicates malfunctioning of the drainage system. All drainage curb channels are blocked and, hence, drain openings through the slab are ineffective. The area around the opening pipes are severely deteriorated.			

Figure 4.47 *Typical Condition of Bearing with Tears, Deterioration and Split*

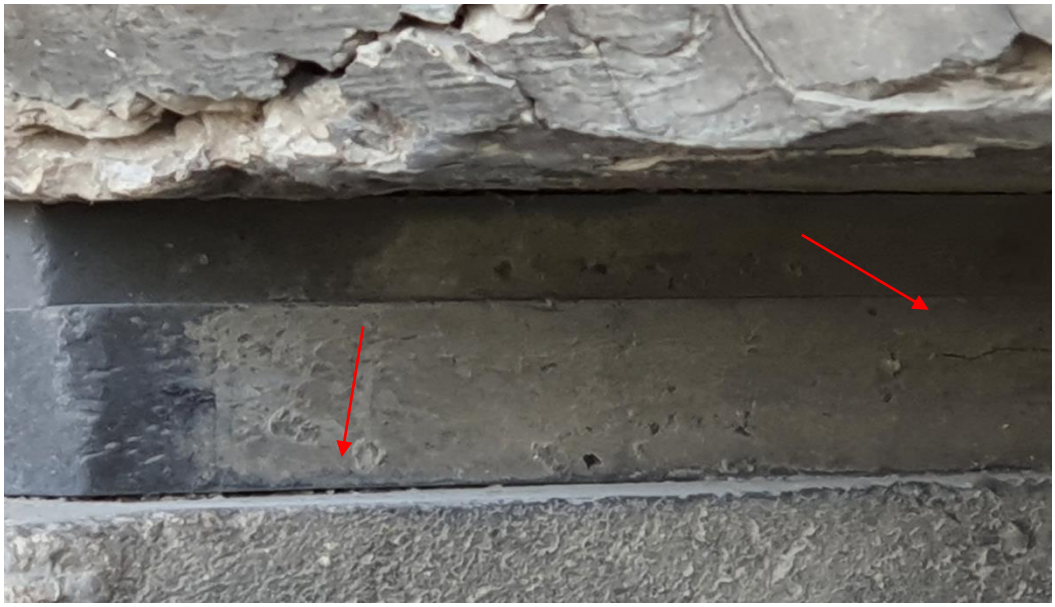


Figure 4.48 *Typical Condition of Bearing with Tears, Deterioration and Split*

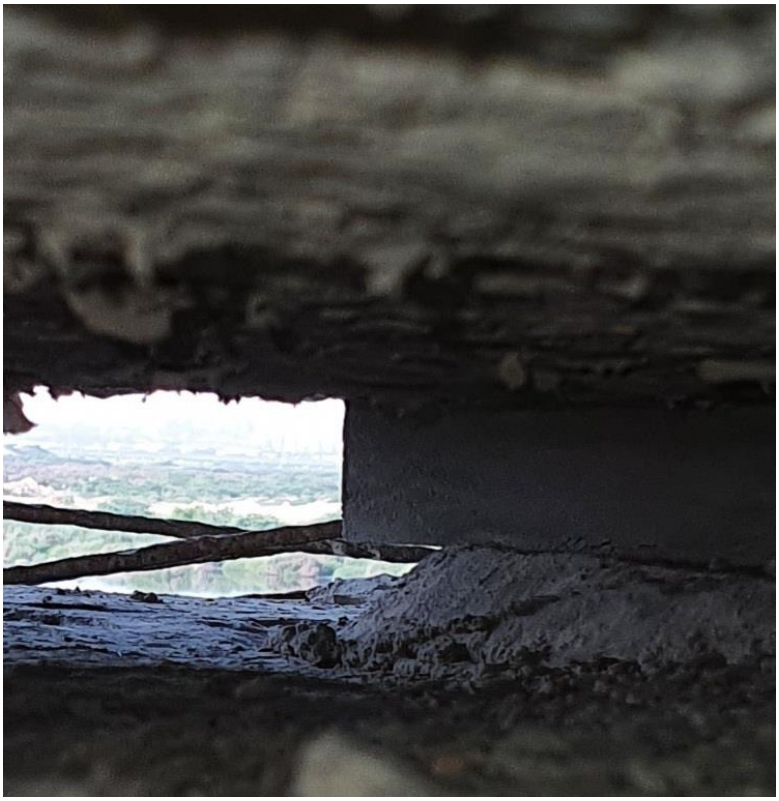


Figure 4.49 *Partial Loss of Bearing Seating and Bearing Deterioration at Axes 15 and 10*

Figure 4.50 *Typical Deterioration State of the Neoprene*

Figure 4.51 *Debris Totally Blocking Bearing Movement*

Figure 4.52 *Bearing Deterioration, Splitting and Tearing*

Figure 4.53 *Typical Condition of the Expansion Joint and Drainage*

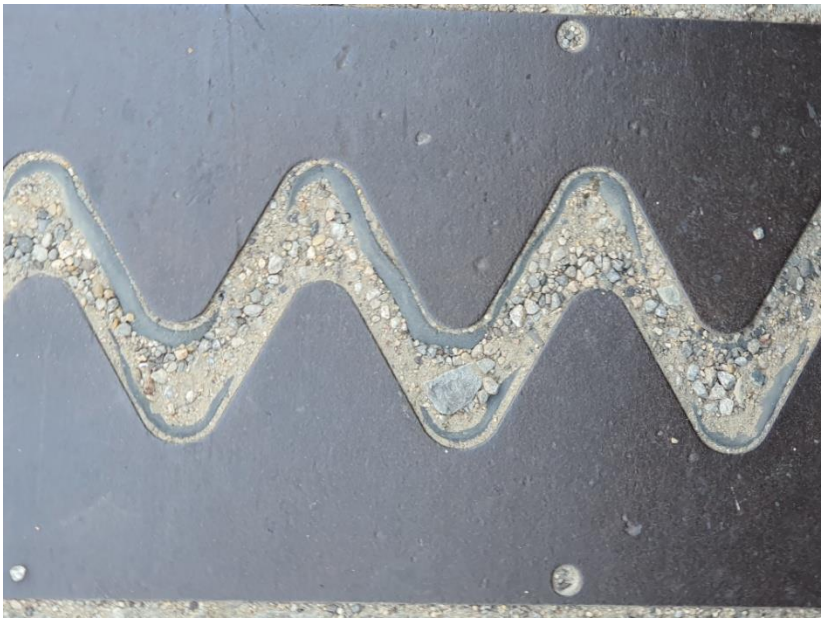


Figure 4.54 *Typical Condition of the Expansion Joints*

Figure 4.55 *Typical Condition of the Sidewalk and Barrier*

4.3.8 INSPECTION MAIN FINDINGS

Main findings from the inspected regions of the bridge revealed the following:

1. Bridge elements, especially piers, pier caps, and slabs are severely affected by corrosion, with several spalls and cracks at critical load bearing zones. The distribution of severity of defects condition states is presented in Appendix A.
2. Several of the defected elements are in critical condition requiring fast track action and replacement including waterway spans which show considerable downward difference in level when comparing surveys of 2019, 2021 indicating expected critical settlement as previously explained in 4.3.3.1.
3. Several of the defected elements were previously repaired but are still in defect progression and their replacement is mandatory.
4. Bridge slabs and girders and a number of piers have a typical critical defect of very low (near zero) concrete cover in several regions. Cover of transoms are observed having less than 30mm in several locations. This inherent defect all-over the structure impacts the effectiveness of any possible repair.
5. From visual observation several parts of the concrete have high surface void ratio, honeycombing and hence high porosity.
6. Bridge bearing elastomeric material is deteriorated with signs of tearing, splits and apparent material disintegrations.
7. Bridge expansion joints are totally blocked with debris and their seals are damaged and non-effective as it is evident from the severe storm water and utility pipe leakages on the bridge elements.
8. Bridge drainage system is halted and not functioning as evident from the accumulation of debris around the expansion joints.
9. Drainage openings through the deck slabs cause severe corrosion and complete loss of section around the outlet region imposing threat on the bridge users.
10. Bridge concrete guardrail is deteriorated and of poor composition and requires replacement.

5. TESTING PLAN & RESULTS

5.1 TESTING CAMPAIGN

The Consultant devised a plan for conducting an intensive testing campaign to evaluate the characteristics of the bridge materials. The test campaign was designed so that the tests integrate and complement each other in a one overall test matrix. As such, intrusive destructive core testing was minimized by calibrating the results of strength indication tests, namely the rebound hammer (Schmidt hammer) tests, and cut and pull out test (CAPO) to correlate with reliable results of cores from the same locations. In conjunction with the concrete strength tests, reinforcement scanning was performed on several elements to assess the amounts of reinforcement through which the structural section capacities of different elements can be assessed.

In addition to strength tests, chemical tests were conducted since they form a major importance to evaluate the ingress of harmful chemicals such as chlorides and sulphates especially from the exposure to polluted water stream and deck drainage.

Concrete carbonation tests with phynolephethaline solutions were also conducted to assess the propagation of carbonation from traffic and atmosphere which is a supporting factor for the corrosion process.

Porosity to assess the permeability of the concrete was also tested to evaluate the density of the current concrete masses and their ability to resist moisture infiltration causing corrosion.

In summary the types of tests conducted over the whole accessible length of the existing Jam Sadiq bridge are:

- Core Tests per ASTM C42, ASTM C39
- CAPO Tests per ASTM C900
- Schmidt Hammer Tests Per ASTM C805
- Carbonation Tests per EN14630
- Reinforcement Scanning ASTM E1303 equivalent
- Chloride Penetration Tests Per BS 1881 –124
- Sulphate content and Concrete Composition Tests per BS 1881 – 124
- Concrete Absorption Porosity Assessment Tests per ASTM C642

Appendix (B) presents the distribution and intensity of tests along the spans.

5.2 TEST PERFORMANCE & RESULTS

The tests were always performed with maximum caution due to the special nature of the bridge location and condition as previously explained. All the equipment used were properly calibrated before the testing. The testing team is accredited by several local agencies.

5.2.1 CORE TESTS - ASTM C42, ASTM C39

The core extraction procedure followed ASTM C42M (refer to Figure 5.1). The drilling machine used 4" or smaller cutting heads according to the intensity of reinforcement. The machine was powered by a heavy gasoline electric generator on site since there was no electric power source specially when testing over the waterway.

Figure 5.1 *Core Extraction from Pier Cap*

The extracted cores had taken into account the condition of piers and were used to obtain strength results and to correlate rebound hammer results accordingly. The following was observed before, during and after the extraction operation:

- The Consultant examined the proposed core extraction location beforehand to ensure that the location is sound and is representative of the concrete element.
- Steel Rebar Detector Instrument was used to avoid cutting any of the main reinforcement bars. If accidentally a bar was encountered the cutting stopped.

- Refilling all the cut core holes with non-shrink grout immediately after extraction as shown in Figure 5.2.
- Conducting carbonation test on site after extraction.
- Keeping specimen in special plastic bags.

Figure 5.2 *Application of Non-Shrink Grout to extracted core locations*

- Core specimen protection and transportation procedure were followed with care. Capping was performed with sufficient thickness to ensure uniform distribution of the loading on all points on the core surface and to ensure completely plane and parallel ends. All these steps were checked on every test.
- Most of the length to diameter ratios (L/d) were between 1.0 and 1.4, to avoid cutting too much depth into the already deteriorated piers. ASTM C42 correction factors were applied.
- All prepared test specimens were free from rebar.
- The cores were crushed in a compressive testing machine per ASTM C39 at a loading rate of 0.25 MPa/sec. Refer to figures 5.3 and 5.4.

It was observed that the concrete mix contains observable amount of voids and its colour is on the lighter grade. Summary of the strength results are found in Tables 5.1 to 5.3. It was observed from the strength results that there is a high scatter of values leading to a high standard deviation. As the AASHTO recommend, population strength is a function of the standard deviation, this high scatter affected the reduction of the average strength by a value of 1.65 of the standard deviation. ACI 318 considers for the probability of having in the core mico-cracking effects due to core cutting operations and considers a single specimen successful if reaches 0.85 the target strength.

Figure 5.3 *Core Compression Testing Example*

Figure 5.4 *Core Failure Examples, a) Pier #6 Core, b) Pier Cap #9 Core & c) Pier #36 Core*

Table 5.1 *Piers Compressive Strength Testing Results*

Piers Testing			
Pier #	**Cylinder Compressive Tests**		
	Core Strength (Mpa)	**Schmidt Hammer R No**	**CAPO No**
Abut-			
P1		44.8	26.6
P2	18.2	43.1	
P3	21.7	43.6	26.8
P4	26.7	41.8	
P5	13	42.6	15.3
P6	24.8	40.0	
P7	32	42.5	40.2
P8	26.9	42.0	
P9			
P10	31.8	44.4	28.7
P11	28.9	43.7	
P12	32.3	44.3	14.4
P13	12.2	44.5	
P14		50.1	
P15		43.3	
P16	17.2	45.8	
P17	13.7	46.0	
P18	20	42.2	24.8
P19		30.5	
P20	9.7	44.5	
P21		43.0	
P22	24.4	39.0	
P23		42.0	
P24	8.4	39.5	
P25		37.5	
P26	28.1	42.6	
P27	15.8	41.3	19.7

P28	21.1	40.4	
P29			
P30	25.0	44.1	
P31	18	40.9	22.3
P32	25.6	41.6	
P33	18	36.2	22.1
P34	0.0	37.7	23.4
P35	18	40.5	22.3
P36	12.4	36.8	
P37	13	37.9	15.9
Abut-	17.8		

- Red cells indicate extremely low values possibly attributed to test defects.
- Blue figures indicate values correlated from CAPO results.

Piers (Mpa)	AASHTO	ACI
AVERAGE f'c	22.6	26.6
STDEV	8.0	
Ignoring very low values		
AVERAGE	26.7	
STDEV	4.8	
Statistical f'c	18.8	22.1

Table 5.2 *Pier Caps Compressive Strength Testing Results*

Transom Testing			
Transom #	Cylinder Compressive strength Tests		
	Core Strength (Mpa)	Schmidt Hammer R No	CAPO No
T1	21.93	41.75	
T2	26	40	32.2
T3	21.88	41.75	
T4		40	
T5	19.08	39.25	23.4
T6		41	
T7	14.18	43.75	
T8	27	40.25	34.3
T9	10.08	40	
T10	18.28	39.25	
T11		41.75	
T12	36.07	41.25	
T13		40.5	
T14	15.47	44.5	
T15	16.49	42.25	
T16		41.25	
T17	0	41	
T18	17.83	41.25	
T19	13.51	42.75	
T20		43.5	
T21	29.57	41	
T22		42.5	
T23	28.34	41	
T24		43.75	
T25	31.39	42.5	
T28		40.75	
T29	10.39	37.5	31.2
T30		42.75	
T31	15.69	42.25	
T32		40.5	
T33	30.19		
T34		42.25	
T35	26.46	40.25	
T36	33	38	42.5
T37	20.56	39.75	

- Red cells indicate extremely low values possibly attributed to test defects.

Pier Cap (Transom) (Mpa)	AASHTO	ACI
AVERAGE F'c	21.96	25.83
STDEV	7.87	
Ignoring low values		
AVERAGE	23.85	28.05
STDEV	7.06	
Statistical F'c	12.2	14.35

Table 5.3 *Deck slab and Girders Compressive Strength Testing Results*

Deck & Girder Testing				
pan #	Cylinder Compressive strength			
	Deck Core Test (cylinder-Mpa)	Schmidt Hammer R No.	Girder Core Test (cylinder-Mpa)	Schmidt Hammer R No.
Span-1		48		53
Span-2		52		50
Span-3	12.1	48		50
Span-4		46		48
Span-5		47	18.3	51
Span-6		51		51
Span-7		51		52
Span-8		47		53
Span-9		52		52
Span-10		53		53
Span-11	21.1	53	28.6	51
Span-12		52		52
Span-13		53		52
Span-14		53		52
Span-15		52		52
Span-16		52		52
Span-26		52	16.3	51
Span-27	16.6	52		51
Span-28		52		51
Span-29		52		52
Span-30		53		50
Span-31		52		52
Span-32		51		46
Span-33		53		45
Span-34		52		48
Span-35		53		46
Span-36		52	11.4	46
Span-37		54		42

Deck Mpa	AASHTO	ACI
AVERAGE F'c	19.75	23.24
STDEV	3.32	
Statistical F'c*	14.28	16.80

Girder Mpa	AASHTO	ACI
AVERAGE F'c	22.09	25.99
STDEV	6.92	
Statistical F'c*	10.67	12.56

*N/A few Samples

5.2.2 REBOUND HAMMER TESTS ASTM C805

Surface hardness tests for the bridge concretes was done by the Rebound Hammer (Schmidt Hammer) method. Although it is well founded that the surface hardness of concrete is related to its mechanical compressive strength, the numerous ambiguities influencing the surface conditions and its hardness always lead from experience to derive the statement, "Schmidt Hammer is a Comparative tool". The Consultant used this tool effectively to help widen the extent of strength estimation tests along the bridge without adding more destructive or harmful tests. This was done by calibrating the rebound number and its associated strength results to those obtained from direct core testing at the same locations. Based on this, almost every core tested location was also tested by rebound hammer. Tests were performed bearing in mind the old age of the bridge which might lead to increase in the surface hardness especially in the presence of carbonation. The near surface low covered reinforcement can impose local effects on the readings. Moreover, the numerous air voids found on the surface and near the surface as detected from core examinations tend also to cause another local effect to the readings when the operator tries to avoid them and select solid concrete test points. Due to the above, it was found that the rebound number results of this bridge are not descriptive and could not correlate to the change in strengths obtained from the cores. In fact the numbers for all tests on different members with different concrete mixes gave readings in a very narrow stationary range. The Rebound hammer Type N was used. It is noted that all test locations were cleaned from dust and light surface matter by grind stones before testing. Each test was composed of 15 hammer readings. The results from the hammer tests presented in Appendix C are listed in the strength Tables 5.1 to 5.3.

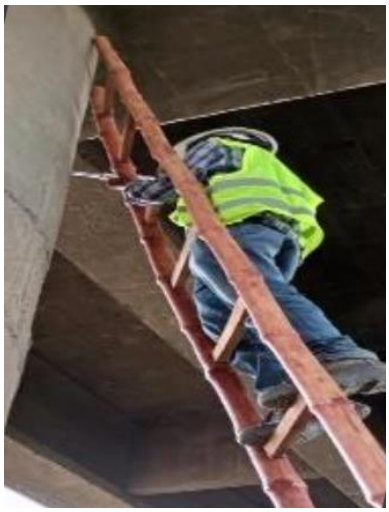


Figure 5.5 *Rebound Hammer Testing*

5.2.3 CUT AND PULL OUT (CAPO) TESTS

Similar in concept to the rebound hammer in depending on the surface strength, the cut and pull out measures the required force to tear out a cylindrical portion from the concrete cover. This force is proportional to the compressive strength of the cover region but not to the internal concrete strength. The results indicated from this test were found to give better correlation and indication than the rebound test. The direct results are given in the strength Tables 5.1 to 5.3.

Correlated to core, CAPO strengths are also given in the core test column in blue color and they show good correlation with core results.

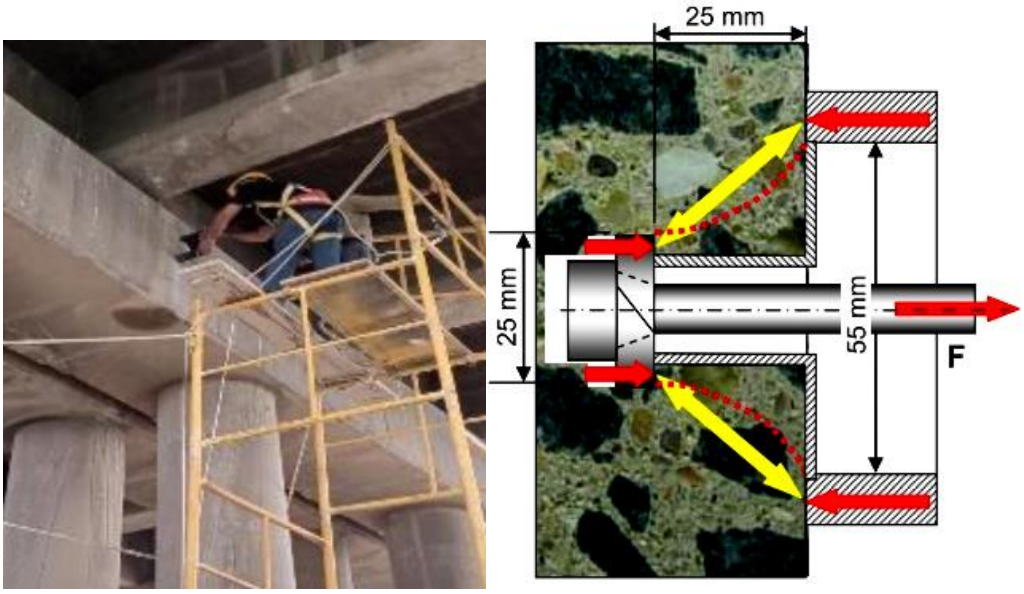


Figure 5.6 *CAPO Test Method*

5.2.4 CARBONATION TESTS - BS EN 14630

Carbonation infiltration of the concrete exposed to air carbon dioxide, causes a reduction in the concrete's alkalinity. The alkaline medium around the steel reinforcement protects it from corrosion. However with this reduction in alkalinity of less than PH=9 due to carbonation, the probability of corrosion of reinforcement becomes higher. Spraying a freshly cut surface of the concrete with phenolphthalein is commonly known and used in this testing program for the determination of the depth of carbonation for several elements. A stayed grey part of the concrete indicates its carbonation while those parts which change to pink color are not carbonated yet. As shown in table 5.4, the depth of carbonation of the structural elements on the bridge ranged within (25-130mm).

Table 5.4 *Depth of Carbonation for Different Bridge Elements*

Element Category	Depth of Carbonation (mm)	Remarks
Piers	42-130 H	Past Reinforcement
Pier Caps	27-50 (one at 230)	Past Reinforcement
Deck Slab	75-130 H	Past Reinforcement

5.2.5 CHEMICAL ANALYSIS TESTS, CHLORIDES, SULPHATES, CEMENT CONTENT BS1881-124

Concrete usually provides its natural protection against the corrosion to reinforcement due to the alkaline medium provided by the cement paste in the mix. The adequacy of this natural protection is often threatened by several possible and practically common factors such as:

- Decrease of the concrete cover thickness which is apparent from inspections,
- Voids entrained in the concrete mass also apparent from observation and tests,
- Degree of exposure to carbonation
- And most importantly, the degree of exposure to chlorides. The bridge elements are exposed to running storm water through leaking drainage and expansion joints as well as leaking fluids from broken utility pipes over the deck and from infiltration from the water stream.

Two types of chloride content investigations were done. One was to determine the near surface chloride concentration from a core, the second was to slice the core into 25mm slices, grind them and obtain the concentration change of the chloride with depth. Both results for the tested cores are shown in the Table 5.5 as detected from the result reports found in Appendix-C. It is apparent that the chloride contents are high with respect to the code limits from ACI 318 given as 0.15-0.3% by cement weight for this bridge exposure. It is found from the results also shown in Table 5.5 that the chlorides go up to 5-10 times higher than the allowable limit which explains the severe corrosion and concrete deterioration.

Sulfates are also found to be more than 4 times higher than the allowable code limit. It is also noticed that the chloride diffusion profile is reversed with respect to the normal diffusion profiles which can indicate genuine chloride contaminated of mix ingredients washed out by pure running water at the surface from above.

Table 5.5 *Chloride & Sulfate Concentrations*

Element Category	Chloride Concentrations % (25-50-75mm)	Sulfates %	Cement Content	Comments
Piers	0.6-1.1-1.65 H	8.5 H	14%	H= High
Pier Caps	0.5-1-1.4 H	9.1 H	14%	
Girders	0.8-1-1.44 H	8.75 H	14%	
Deck Slab	0.65-1-1.15 H	9.65 H	14%	

5.2.6 POROSITY & ABSORPTION RATIO ASTM C642

As previously discussed in Clauses 4.3.7 & 5.2.1 it was observed from the inspections that different elements contain a considerable number of apparent voids. This fact together with the extensive corrosion observed lead to the need to investigate the ability of concrete to resist infiltration of moisture from leaked storm water or other fluids from the untreated waste channel or the utility carriers on deck. Permeability is commonly expressed in terms of absorption, void ratio or porosity. ACI 301 sets an upper limit of 6.5% voids for normal concrete. It is to be noted that for durable dense concrete the void ratio limit is around 3%. Pervious concrete is often defined to have void ratios starting at 15 to 20%. The results of void ratio obtained from tests on different Jam Sadiq bridge elements reported in Appendix-C and summarized in table 5.6, reached up to 14% in several cases near the limit of pervious concretes. This reflects the inspection observations of the large surface void ratios and further confirms the porous nature of the concretes of the bridge, explaining an additional factor of lack of durability and lack of resistance against moisture infiltration.

Table 5.6 *Void Ratio Test Results*

Element Category	Void Ratio	Remarks
Piers	11.4%	High
Pier Caps - Transoms	14%	Very High – Near Pervious Concrete Limit
Deck Slab	10%	High

5.2.7 REINFORCEMENT SCANNING

A number of reinforcement scans were conducted on several elements with results presented in Appendix C. The scan results were used to check the capacities of some elements against intended loading. The relevant parameter to corrosion resistance is the depth of concrete cover to reinforcement, which is obtained from scans. The results of measurements of concrete cover depth proved relatively low depths as was also observed from inspections and are summarized in Table 5.7.

Table 5.7 *Concrete Clear Cover Values Obtained from Scanning*

Element Category	Test Average Depth of Cover (mm)	Observed Low Cover (mm)
Piers	42	15
Pier Caps	37	25
Girders	35	10
Deck Slab	35	5

Fig 5.7 *Hilti Ferro Scanning Apparatus*

5.2.8 TESTING MAIN FINDINGS

From the above results it is evident that the bridge materials and construction parameters have several inadequacies. These inadequacies include:

- Several times higher than code limit chloride and sulphate contents,
- Low compressive strength,
- High porosity,
- Low concrete cover to reinforcement,
- And deep carbonation.

These inadequacies are from material origin, and, hence, are distributed over the whole structure causing complications for the repair process.

6. OVERALL ASSESSMENT OF THE BRIDGE

6.1 HEALTH INDEX RATING

The recorded defects are used to calculate the health index of the elements according to AASHTO MBEI. The health index of the elements is calculated using the below equation:

$$He,d = \frac{100}{\sum_{s=1}^{4} q_{s,d}} \sum_{s=1}^{4} \left(\frac{4-s}{3}\right) q_{s,d}$$

The health index rating of the inspected bridge components, the deck slab, the girders, the pier caps and the piers are provided in the color-coded layout in Appendix (A). It can be seen that several bridge non-redundant elements such as the transoms have severe condition states (red) which highlights an alert.

Based on the above detailed inspection data, the bridge is assessed to be in an overall AASHTO health condition state of “Poor” and several parts of the bridge are in a condition state “Severe”. The overall health index of the bridge is 0.44, promoting the bridge as eligible for replacement according to FHWA & AASHTO. Appendix A presents with the element health indices, summary of the overall health index of the bridge.

6.2 DEGRADATION RATE

It is well established as one of the operations of bridge management systems to form degradation matrices based on actual condition assessments from different inspection cycles. Jam Sadiq bridge had been repaired during 2015 and at that time it is expected that at least major cracks, spalls and defects had been remedied. As from the obtained inspection data and condition states of 2021 and from part of the 2019 inspection data performed during preliminary design, a degradation model for the status of the bridge could be built through degradation matrices. Up to this end the degradation trend could be estimated from actual condition-based assessments. This estimation can be visualized from the below Figure 6.1.

2015-2021 Degradation Rate

2015 \ 2021	Good	Fair	Poor	Severe
Good	17.8%	28.8%	15.4%	18.0%
Fair	0.0%	0.0%	6.5%	13.5%
Poor	0.0%	0.0%	0.0%	0.0%
Critical	0.0%	0.0%	0.0%	0.0%

H.index 0.44

2015-2019 Degradation rate

2015 \ 2019	Good	Fair	Poor	Severe
Good	46.7%	5.0%	28.3%	0.0%
Fair	0.0%	15.0%	5.0%	0.0%
Poor	0.0%	0.0%	0.0%	0.0%
Critical	0.0%	0.0%	0.0%	0.0%

H.index 0.71

Average Health Index Degradation Rate = . (100- w. Hx)/5 = 11.2% / Year in 6 years 53.4% of the unrepaired now good/fair elements will be in poor/severe condition

Critical Element Degradation Rate = (100-46.6)/5 = 10.70% / year In 6 Years, an element that is now good/fair can become poor/critical

Piles "U" unknown foundation per condition extrapolation shall be as piers/pier caps at least

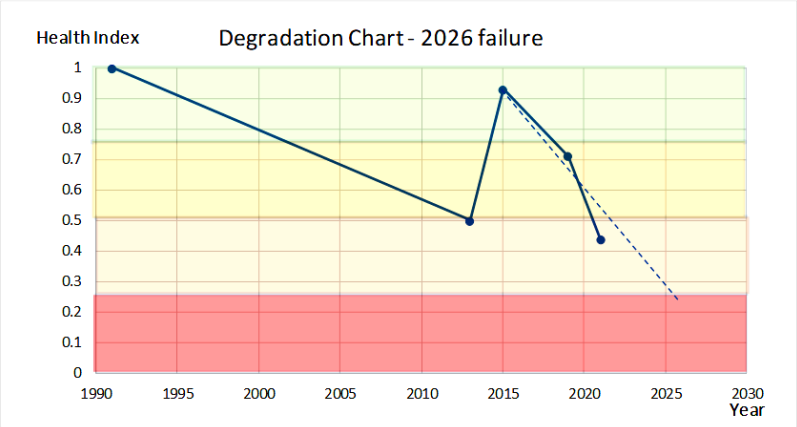


Figure 6.1 *Evaluation of degradation trend from Condition Based Degradation Matrices*

It can be detected from the degradation trend that the expected remaining life span to reach an overall critical or failure condition of the bridge (without repair) is about 5-6 years (year 2026-27). This does not overrule the possibility of having local element failures before this date. Replacements of parts of the bridge as well as intensive repairs for other parts are mandatory to avoid imminent failures.

Other methods are also used to estimate the current rate of degradation and the remaining life expectation such as the methods applicable for existing structures in ACI365 and ASTM 1566 below.

- **Method A- Fick's Second Law of Diffusion Applicable to Existing Structures (ASTM1566)**

  For Substructure exposed to soil such as exposed piles or pile caps,

  Soil percentage chloride from 2019 borehole (15) = 0.15% (1500 ppm)

  Soil density = 1.8 t/m3 and concrete unit weight = 2.5 t/m3

  Average concrete porosity of piers from absorption tests= 11.49% (from tests)

  Then, the chloride load concentration at surface from soil contamination is:

C_{omax} = 0.15*1.8*.1149/2.5 = 1.24%

This value is considered high.

From Cement weight content test, cement weight = 14% concrete weight in the bridge mixture.

Allowable limit for ACI exposure C2 in soil with brackish water = 0.15%, however for assessment of actual condition purpose we adopt the limit for ACI normal exposure category C1 =0.3% knowing that the calculation is for a check of actual condition then the threshold chloride value at reinforcement will be used as 0.3% from cement weight (C_t)

C_t = 0.003/0.14= 0.022,

Per ASTM C 1566, Ficks second law of diffusion is used with a measurement chloride content of 0.6% at 12mm

$$C(x,t) = C_0[1 - erf(x/2(D_{cl}t)^{1/2})]$$

To estimate the error function erf, it is found that the value of $\frac{x}{2.\sqrt{D_{cl}.t}}$ is in the range of (0.2 – 0.7) and hence it can be considered the same value of its variable according to Bayer Handbook of Mathematics 5th edition.

$$\frac{C_{xt}}{C_o} = 1 - \frac{x}{2.\sqrt{D_{cl}.t}}$$

$$\frac{x}{2.\sqrt{D_{cl}.t}} = (1 - \frac{C_{xt}}{C_o})$$

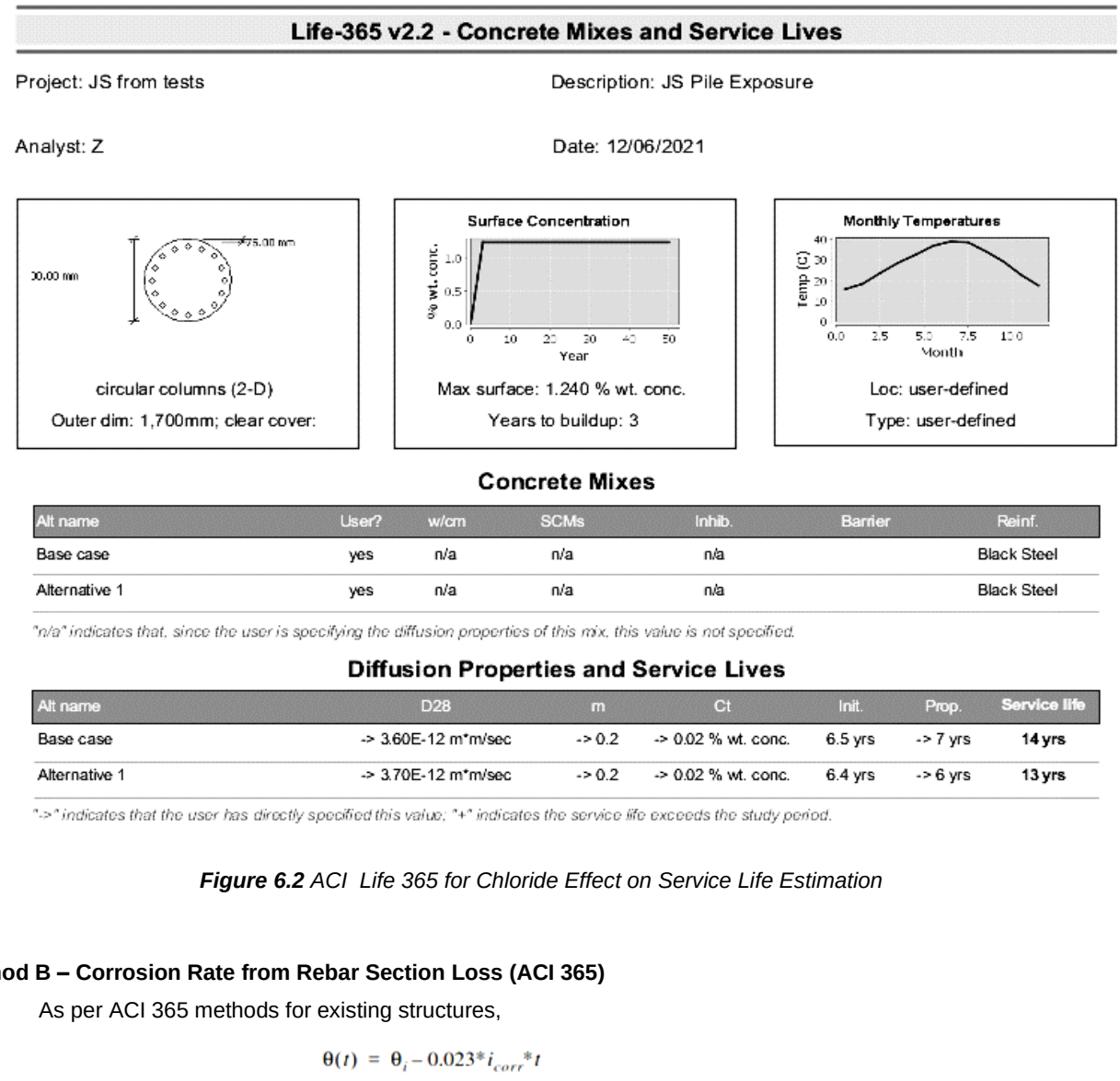
$$\frac{x^2}{4} . \frac{1}{(1-\frac{C_{xt}}{C_o})^2} = D_{cl}.t$$

By back calculations from the measured chloride concentrations through the 30 year current life span and 10 years of stream pollution exposure, the chloride diffusion coefficient of the material can be estimated as D_{cl}. Then, the threshold concentration to reach the deepest cover of 75 mm for soil exposed substructure, and as per the measured cover for the rest of elements “t” – the remaining life- ranges between zero to 15 years with an average of about 6-7 years as shown in Table 6.1.

Table 6.1 Chloride Diffusion & Estimated Remaining Life

From Element	C_{0max} Surface	$C_{x,t}$	x	t Exposure (Year)	Time Conv.	D_{cl}	x/(2 .√(Dcl.t))	D_{cl}	C_{0max}	Est. Ct	Ets. x	t Remainaing (year)
Piers slice 1	0.13	0.09	0.025	30	3E+07	2E-12	0.28	2E-12	1.24	0.022	0.075	15.7
Piers slice 2	0.17	0.13	0.025	30	3E+07	3.2E-12	0.23	3.2E-12	1.24	0.022	0.075	7.3
Piers Slice 1-3	0.20	0.09	0.075	30	3E+07	5.2E-12	0.53	5.2E-12	1.24	0.022	0.075	1.8
Pier 8	0.15	0.06	0.075	30	3E+07	4.1E-12	0.60	4.1E-12	0.62	0.022	0.075	4.6
P11	0.19	0.05	0.075	30	3E+07	2.7E-12	0.74	2.7E-12	0.62	0.022	0.075	10.5
P12	0.18	0.07	0.075	30	3E+07	4E-12	0.61	4E-12	0.62	0.022	0.075	5.0
P13, 16	0.20	0.08	0.075	30	3E+07	4.1E-12	0.60	4.1E-12	0.62	0.022	0.075	4.6
P 20	0.21	0.09	0.075	30	3E+07	4.6E-12	0.57	4.6E-12	1.24	0.022	0.075	3.2
P22	0.20	0.09	0.075	30	3E+07	4.9E-12	0.55	4.9E-12	1.24	0.022	0.075	2.4
P24	0.22	0.08	0.075	30	3E+07	3.7E-12	0.64	3.7E-12	1.24	0.022	0.075	5.6
P26	0.19	0.07	0.075	30	3E+07	3.7E-12	0.63	3.7E-12	1.24	0.022	0.075	5.4
P28	0.21	0.11	0.075	30	3E+07	5.8E-12	0.50	5.8E-12	0.62	0.022	0.075	1.2
P30	0.22	0.12	0.075	30	3E+07	7.2E-12	0.45	7.2E-12	0.62	0.022	0.075	0.0
Transom Slice 1	0.10	0.08	0.025	30	3E+07	3.6E-12	0.22	3.6E-12	0.06	0.022	0.045	4.3
Transom Slice 2	0.12	0.10	0.025	30	3E+07	5.7E-12	0.17	5.7E-12	0.06	0.022	0.045	0.1
Transom Slice 1-3	0.20	0.08	0.075	30	3E+07	4.1E-12	0.60	4.1E-12	0.06	0.022	0.045	2.7
Deck Slice 1	0.17	0.14	0.025	30	3E+07	6.5E-12	0.16	6.5E-12	0.6	0.022	0.165	5.9
Deck Slice 2	0.20	0.17	0.025	30	3E+07	7.5E-12	0.15	7.5E-12	0.6	0.022	0.165	1.1
Deck Slice 3	0.24	0.20	0.025	30	3E+07	7.2E-12	0.15	7.2E-12	0.6	0.022	0.165	2.2
Deck Slice 1 -3	0.24	0.14	0.075	30	3E+07	8.8E-12	0.41	8.8E-12	0.6	0.022	0.165	0.0

This method is further verified using the software Life365© with default ACI 365 assumptions and test results and the estimated life span from start of exposure is 14 year as presented in Figure 6.2 from 2011 (onset of river enlargement and main pollution). This means about 4 years are remaining and this conforms to the result from the chloride diffusion estimates and the degradation matrices above. This should be well guarded during the next stages since bridge elements with the least or no repairs will be affected by this short life span criterion. This requires studying and applying all safety and durability concepts in any coming phases.



Life-365 v2.2 - Concrete Mixes and Service Lives

Project: JS from tests — Description: JS Pile Exposure

Analyst: Z — Date: 12/06/2021

Concrete Mixes

Alt name	User?	w/cm	SCMs	Inhib.	Barrier	Reinf.
Base case	yes	n/a	n/a	n/a		Black Steel
Alternative 1	yes	n/a	n/a	n/a		Black Steel

"n/a" indicates that, since the user is specifying the diffusion properties of this mix, this value is not specified.

Diffusion Properties and Service Lives

Alt name	D28	m	Ct	Init.	Prop.	Service life
Base case	-> 3.60E-12 m*m/sec	-> 0.2	-> 0.02 % wt. conc.	6.5 yrs	-> 7 yrs	**14 yrs**
Alternative 1	-> 3.70E-12 m*m/sec	-> 0.2	-> 0.02 % wt. conc.	6.4 yrs	-> 6 yrs	**13 yrs**

"->" indicates that the user has directly specified this value; "+" indicates the service life exceeds the study period.

***Figure 6.2** ACI Life 365 for Chloride Effect on Service Life Estimation*

Method B – Corrosion Rate from Rebar Section Loss (ACI 365)

As per ACI 365 methods for existing structures,

$$\theta(t) = \theta_i - 0.023 * i_{corr} * t$$

where
$\theta(t)$ = steel reinforcement diameter at time t, mm;
θ_i = initial diameter of the steel reinforcement, mm;
i_{corr} = corrosion rate ($\mu A/cm^2$);
t = time after the beginning of the propagation period, years; and
0.023 = conversion factor of $\mu A/cm^2$ into mm/yr.

From inspections an intact rebar of 16mm in 2015 is now having an equivalent diameter of 14.7mm, and by back calculations from site data,

$i_{corr} = 8$

And hence the duration needed to reach critical loss of 30% of an intact rebar would be 7 years from 2021 assuming intact rebar existed in 2015,

Method C - Effect of Carbonation

The relation between carbonation depth d_c and age T in years depends on several factors including the w/c ratio and proportions of the concrete mix as well as the type of cement and environment, however all these factors can be summed in the proportionality factor A to represent the relation by the below equation.

$$d_c = A \sqrt{T}, \quad \text{where t is the time in years,}$$

Assuming the current average carbonation depth of piers = 70mm (as from some test results), A is determined by back calculations as

A = d_c/ (30)^0.5 = 12.78 (depending on mixture composition, cement type, w/c, etc)

This depth is past reinforcement depth explaining one of the factors causing severe distributed corrosion in most piers. However, if other piers have well deep reinforcement up to 75mm covered the time needed for the carbonation to reach this good reinforcement will be after 4.5 years according to the above calculations.

6.3 MIDDLE SPANS SETTLEMENT

Critical condition of settlement is detected from comparing the results of the current 2021 top survey results with the matched results from the 2019 topo survey for the running elevation spans (the checks excluded the ramps) as explained for the more affected middle spans in 4.3.3.1. This condition requires immediate fast track action for safety and removal/replacement of these spans based on the reliability of these surveys.

Although 2019 survey data was limited, and as new topo survey was conducted in 2021. An attempt was made to link the two surveys. Since 2019 survey was based on different benchmarks and coordinate system than those for 2021 survey the two surveys couldn't be directly compared. However, observing the trends in both surveys and assuming that the two surveys are linked at gird axis 10 at the highest elevation of both showing only 20mm difference at this point, It was detected that the difference in elevation of the deck at pier locations for the spans of the running part of the bridge increase up to 100mm in 2021 lower than the 2019 survey. Furthermore, the 2021 survey itself show up to 150mm difference between axis 10 and axis 20 as previously commented in Section 4.3.3.1. This can indicate a very serious settlement movement unless it can be confirmed that the source of the results difference is from otherwise reason such as original profile. This value of settlement is considered critical and it is assessed that the foundations of these spans are in critical condition requiring critical fast track action. Figure 6.3 shows the elevation differences detected from both surveys.

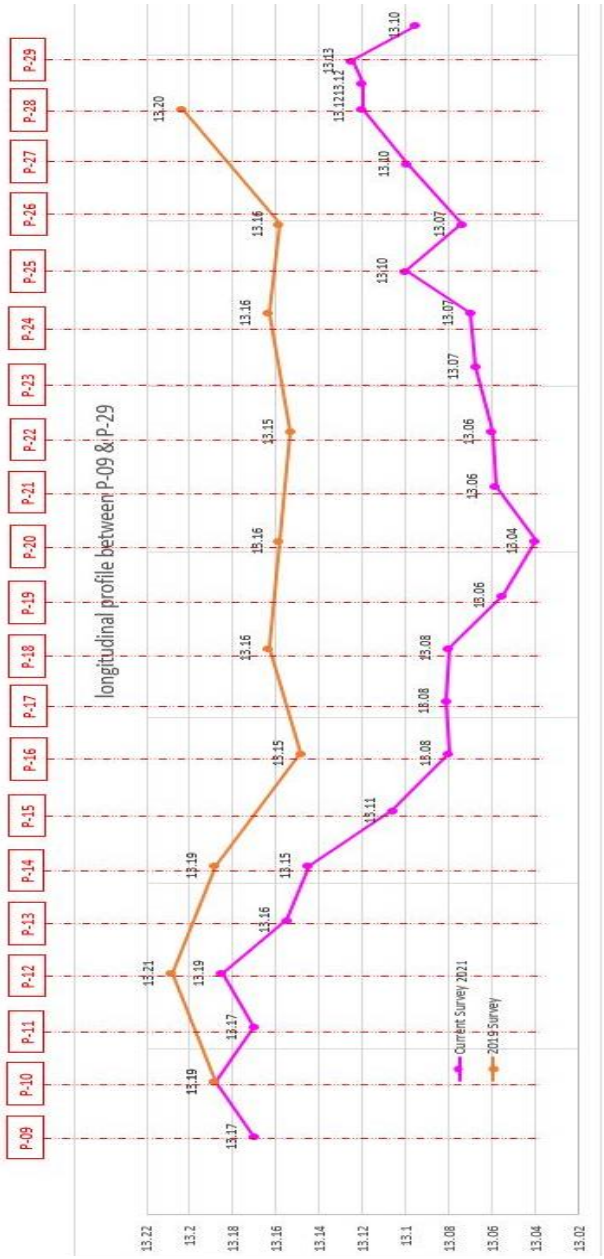


Figure 6.3 *Critical Difference in Top of Deck Levels from 2019, 2021Topo- Surveys*

6.4 CAPACITY CHECKS

A series of capacity checks were performed on some structural elements with the updated current code loads and it was found that some of these elements are in critical capacity condition even if not defected.

7. PROPOSED REHABILITATION & PROTOCOL

7.1 MAIN REHABILITATION SCHEME

Based on the investigations and on the testing, campaign conducted a number of rehabilitation and actions are preliminarily proposed and their feasibility is discussed in section 7.2. The proposed actions include the following:

- Total replacements of severely deteriorated elements and spans including possibly affected by settlement waterway spans. This condition requires immediate fast track action for safety and removal/replacement of these spans.
- Jacketing and complete rehabilitation of the poor condition elements and augmentation of cover for the low cover elements.
- Patch repairs of different types whether full depth or half depth with rebar replacement for the fair condition elements.
- Superficial patch repairs mostly for some parts of the fair and good condition elements.
- Replacement of bridge bearings
- Replacement of expansion joints and introduction of sealing system.
- Rehabilitation and alteration of drainage system
- Replacement of side barriers.
- Replacement of Waterproofing
- Replacement of pavement and wearing course.

The distribution of the proposed preliminary rehabilitation schemes along the layout of the above is given in the preliminary Tender Drawings presented in Appendix (A).

7.2 FEASIBILITY

It should be decided on the feasibility of conducting such intense rehabilitation scheme for a bridge that already underwent multiple repairs in the past and is still deteriorating and is near its end of service life. This is especially in contrast to the new bridge under design and construction. A summary of the principle replacement and repairs of the existing bridge includes:

- Replacement of 9 spans out of 38.

- Replacement of additional 3 pier bents with their pier caps out of a total 37.
- Replacement of additional 19 span deck slabs out of 37 spans inspected.
- Replacement of bridge bearings.
- Replacement of bridge expansion joints.
- Jacketing of additional 11 pier caps out of 37.
- Jacketing of piers on 4 axes out of 37.
- Major repairs on 6 span girders and slabs.
- Several distributed patching and injection works in all remaining elements.
- Expected partial deep foundation rehabilitation conjugate to the inspected defects aboveground.
- Restrict passage of large size vehicles such as trucks until safety is guaranteed by repair.

The amount of the intended repair and replacements sums at a rehabilitation budget of approximately $5.2M (excluding possible repair need for foundation as could be detected during the works). The amount is comparable to about 25% of the estimated construction cost of the new bridge. The amount and cost of rehabilitation and element replacement required for the bridge to serve in the under development Yellow Line BRT project is considered from the JV assessment view not feasible (based on the available data) for the short remaining life span expectancy. Hence the bridge is recommended for “replacement”.

8. CONCLUSION & RECOMMENDATIONS

The Jam Sadiq Bridge was inspected in October 2021. This report provides the bridge assessment from field inspections and testing of the accessible parts of the bridge. The overall condition for the bridge and recommendation are summarized as follows:

- Based on the above detailed inspection data, the bridge is assessed to have an overall AASHTO health index of (0.44) with condition states of main components ranging from “Poor” to “Severe” as demonstrated in Appendix (A).. The overall health rating of the bridge qualifies the bridge as eligible for replacement according to FHWA & AASHTO.
- Topographic survey data comparison from 2021 and 2019 show significant settlement difference (Sections 4.3.3.1, 6.3) and imposes a critical condition which requires fast track action.
- Based on testing, the bridge materials and construction have several inadequacies. These inadequacies include several times higher than code limit chloride and sulphate content, low compressive strength, high porosity, low reinforcement cover, and deep carbonation. These inadequacies are distributed over the structure for they are of material origin.
- The bridge condition requires different schemes of actions which include replacements, jacketing and repairs for different elements as elaborated in the report and Tender Drawings.
- The detailed design will require further verification of the adequacy of the deep foundations and their durability state.
- The amount and cost of rehabilitation/ element replacement for the bridge as per Section 7, and in light of the adjacent new bridge under development, is considered not feasible (based on available data) for the short life span expectancy and hence the bridge is recommended for “replacement”.

9. APPENDIX A - CONDITION RATING RESULTS & REHABILITATION

Table A-1 Inspected & Tested Elements Ratio

Item	Number	Percentage
Total number of spans	38	
Spans visually inspected	37	97%
Spans tested	38	100%

Table A-2 Number of Elements in Each Condition State & Health Indices

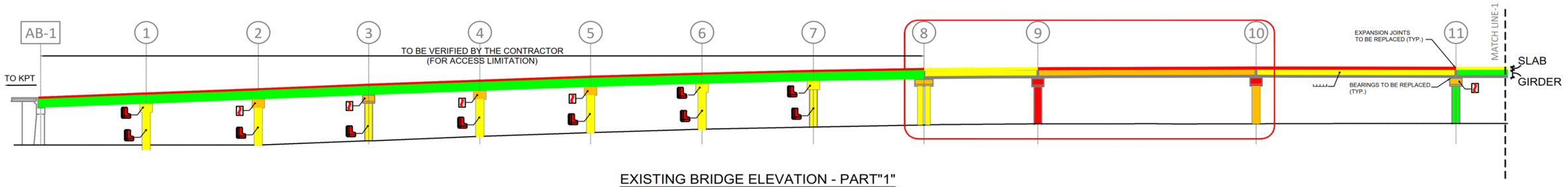
AASHTO Cond. St.	Pier Axis		Pier Cap		Deck Slab		Girder		Bridge
	No	%	No	%	No	%	No	%	
Good	5	13.5%	4	10.8%	1	2.7%	16	43.2%	26
Fair	16	43.2%	9	24.3%	3	8.1%	15	40.5%	43
Poor	7	18.9%	14	37.8%	6	16.2%	6	16.2%	33
severe	9	24.3%	10	27.0%	27	73.0%	0	0.0%	46
SUM	37	100.0%	37	100.0%	37	100.0%	37	100.0%	148
Health Index	0.49		0.40		0.13		0.76		0.44

Table A-3 Number of Repaired Elements from Inspections,***

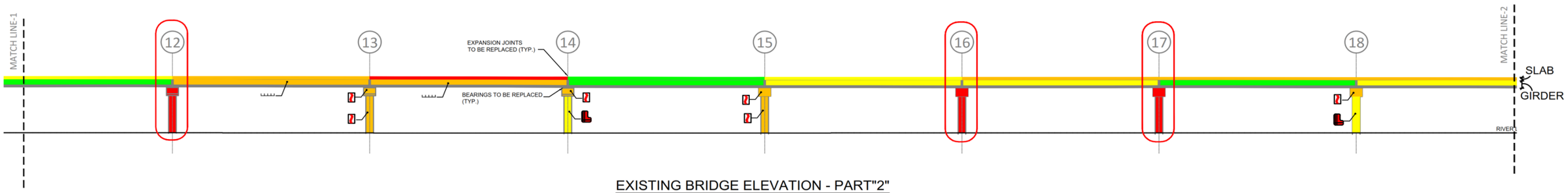
Element	Replacement		Major Repair		Minor Repair		Total Number
	No.	%	No.	%	No.	%	
Pier Axis	15	40.5%	4	10.8%	18	48.6%	37
Pier Caps	15	40.5%	11	29.7%	11	29.7%	37
Deck Slabs	28	75.7%	6	16.2%	3	8.1%	37
Girders	6	16.2%	6	16.2%	25	67.6%	37

** All Bearings, Expansion Joints, Barriers, Drainage and Wearing course to be Replaced.*

*** Doesn't include piles and foundation for the settlement spans and as could be revealed during the works.*



EXISTING BRIDGE ELEVATION - PART"1"



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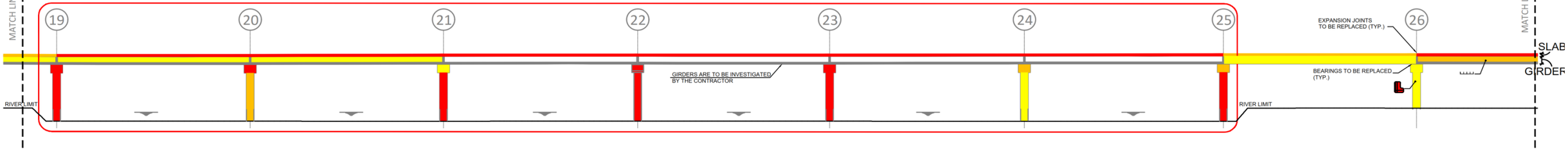
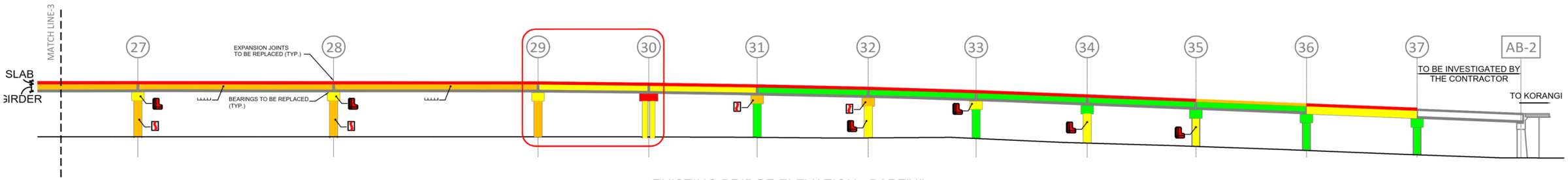


EXISTING BRIDGE ELEVATION - PART"3"



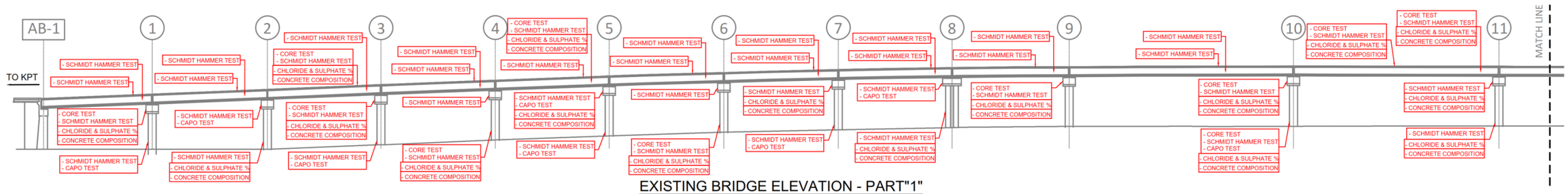
EXISTING BRIDGE ELEVATION - PART"4"

LEGEND:

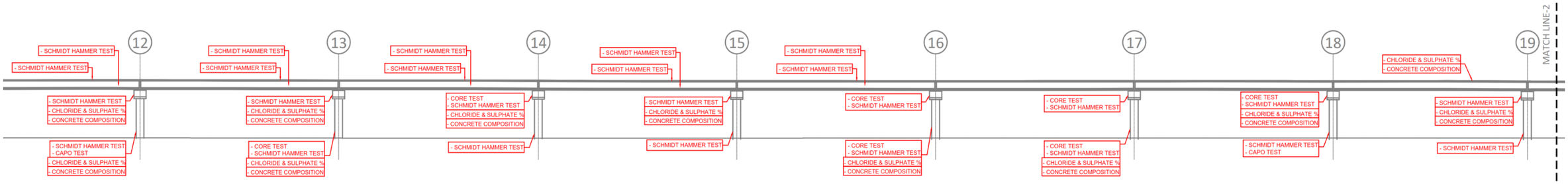
GOOD	PATCHING REPAIR
FAIR	PATCHING D / CRACK / PATCHING S REPAIR
POOR	- FULL JACKETING FOR PIERS & TRANSOMS REHAB. - COVER TREATMENT / PATCH / CRACK REPAIR FOR GIRDERS/DIAPHRAGMS REHAB.
SEVERE	REPLACEMENT
MARKED ELEMENTS ARE AASHTO ELIGIBLE FOR REPLACEMENT	

Fig A.1 Condition Health Indices of Bridge Components

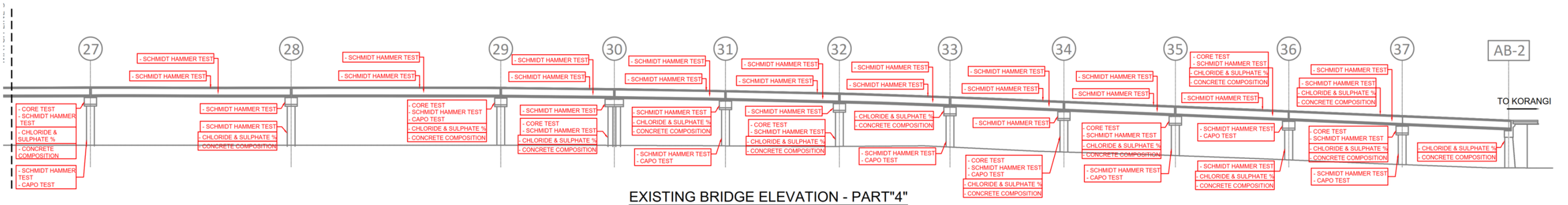
10. APPENDIX B – TEST CAMPAIGN



EXISTING BRIDGE ELEVATION - PART"1"



EXISTING BRIDGE ELEVATION - PART"2"



EXISTING BRIDGE ELEVATION - PART"3"

EXISTING BRIDGE ELEVATION - PART"4"

Fig B.1 Distribution of Performed Tests on Spans

11. APPENDIX C - TEST RESULTS

HIRING OF SERVICES FOR CONDUCTING TESTS

AT JAM SADIQ BRIDGE KARACHI

Performed by

www.fnmengineering.com

DEPARTMENT OF CIVIL ENGINEERING

Bahria Town Address: OSAF Plaza 138B-Midway Commercial B Bahria Town, Opposite Masjid-e-Sarwar.
Cell: 0311-3996176, 0300-1711012

Head Office: Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal Karachi, Pakistan
Tel: 021-34973000 / 021-34974000 Cell: 0331-5954457

HIRING AND SERVICES FOR CONDUCTING TEST AT JAM SADIQ BRIDGE, KARACHI

National Engineering Services (Pvt.) Limited (NESPAK)

13th Floor, NICL Building, Abbasi Shaheed Road, Off Shahrah e Faisal, Karachi-74400, Pakistan

14th October to 30th November

J01-0003-10/21

Prepared by	Laboratory	Approved by
Raheel Shaikh **Asst Manager**	**Jawwad Naseem** **Lab Manager**	**Imran Muhammad Arif** **Managing Partner**

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
INTRODUCTION 2
SCOPE OF WORK 3
PICTORIAL PROOF OF INSPECTION 4
VISUAL INSPECTION 5
NON-DESTRUCTIVE TESTING 6
REBOUND HAMMER TEST 7
FERRO SCANNING AND REBAR SCANNING TEST 8
DESTRUCTIVE TESTING 9
CAPO TEST 10
COMPRESSIVE STRENGTH TEST THROUGH CORE RECOVERY 11
CHEMICAL TESTING 12
CHLORIDE CONTENT TEST 13
SULPHATE CONTENT TEST 14
CONCRETE COMPOSITION TEST 15
CARBONATION TEST 16
CONCLUSION 17

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APPENDICES

APPENDIX A – REBOUND HAMMER TEST RESULTS

APPENDIX B – REBAR SCANNING (FERRO SCANNING)

APPENDIX C – CORE EXTRACTION & COMPRESSIVE STRENGTH TEST RESULTS

APPENDIX D – CAPO TEST

APPENDIX E – CHLORIDE CONTENT TEST OF EXTRACTED CORES

APPENDIX F – SULPHATE CONTENT TEST OF EXTRACTED CORES

APPENDIX G – CONCRETE COMPOSITION TEST

APPENDIX H - CARBONATION TEST ON EXTRACTED CORES

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EXECUTIVE SUMMARY

National Engineering Services (Pvt.) Limited (NESPAK) assigned a job to **F & M** Engineering regarding of testing at **Jam Sadiq Bridge, Karachi Pakistan.** F & M Engineering performed following tasks for the assessment of structures which includes visual Inspection of the Bridge structure for major and minor findings, destructive testing and nondestructive testing for the identification of the material strength of the Bridge structural elements.

In non-destructive testing Rebound Hammer Test as per **ASTM C805 – C805M-18** was performed in order to identify the surface strength of the structural elements, and Ferro scanning was performed in order to detect / discover the spacing, diameter and concrete cover of all reinforcement bars at selected test points for all selected structural elements of the bridge.

In destructive testing cores were extracted from structural elements of different areas of the bridge as per **ASTM C42-C42M-20, ASTM C39M, & ASTM C617M** Total around 60 cores were extracted which were transferred to the testing laboratory for further process which includes sharpening, capping and testing.

In destructive testing Capo test were also performed to determine the compressive strength of structure member of different area of bridge as per **ASTM C900-19**.

In chemical testing, Concrete Composition test were performed to determine cement and aggregate content in exhausted cores as per BS – 1881-124.

Chloride and Sulphates content were also determined as per BS-1881-124

Reference Codes and Standards:

- ASTM C42- C42M-20, ASTM C39M-14 & ASTM C617-C617M-15
- ASTM C900 - 19
- ASTM C 1218 / C 1218M-20
- ASTM C805-C805 C805M - 18
- BS 1881, ASTM C 1218M-20

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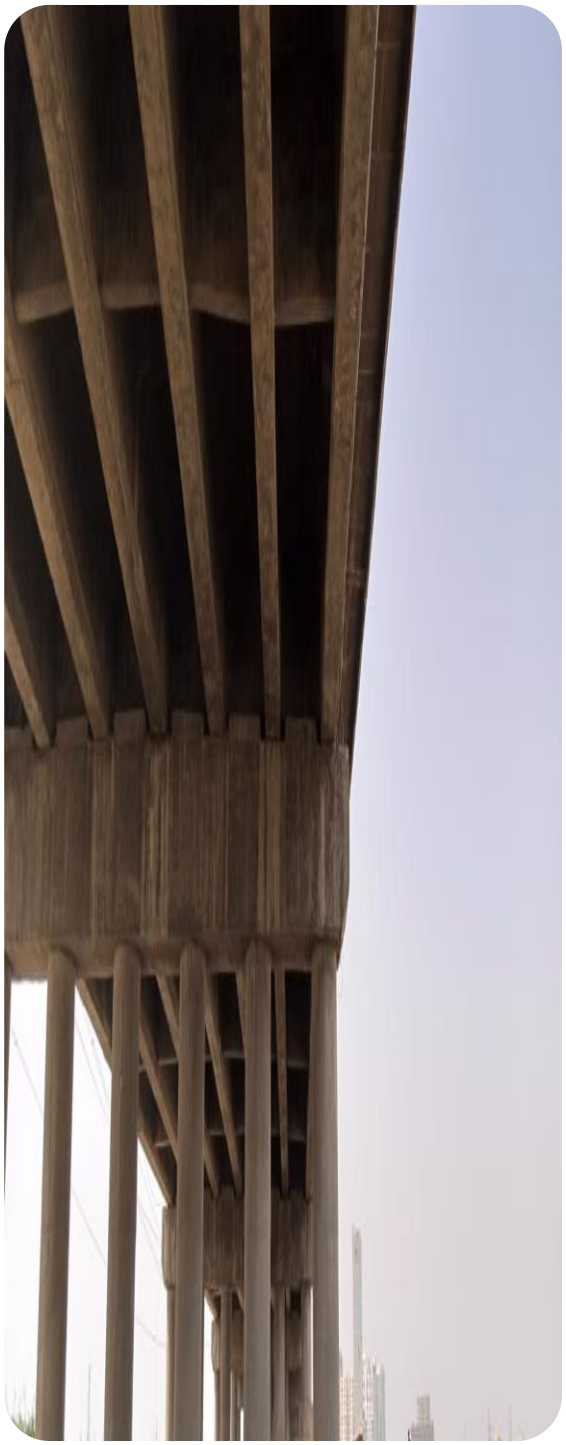
INTRODUCTION & BACKGROUND

F & M Engineering has been assigned the task of testing of Jam Sadiq Bridge by National Engineering Services (Pvt.) Limited (NESPAK). NESPAK and DAR have been working in partnership for detail design and construction supervision of Bus Rapid Transit System (BRTS) - Yellow Line.

Jam Sadiq bridge is located over the Malir River and connects Korangi Industrial area with DHA and beyond.

The bridge is around 1100 m long and was constructed in 1992. It is a four (2+2) lane bridge and has an overall Right of Way (ROW) up to 20 m. It is comprised of simply supported spans on column bents/piers and two abutments, one at each end of the bridge. The structure of the bridge comprises of pre-stressed concrete I-Girders composite with Reinforced Cement Concrete (RCC) deck resting on RCC transom which is supported by RCC piers. NESPAK and DAR, the client has planned using one lane of the Jam Sadiq Bridge for BRTS – Yellow line corridor for which site and laboratory testing of the samples taken from different components of this bridge are required for which F & M Engineering has been assigned to carry out testing of the Jam Sadiq Bridge.



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SCOPE OF WORK

The scope of the work consists of the following:

Visual Inspection

- Visual inspection for major & minor defects / deteriorations on the bridge structure.
- Visual inspection to locate spalling, cracks and other structural defects.
- Visual inspection for bridge structure defects and causes.
- Although the visual inspection of the bridge was not in our scope of services, however we have carried it out by ourselves. The visual inspection consists of following.

Compressive strength and Chemical Test through Core Recovery

- To determine the internal strength of concrete, particularly when used in conjunction with other non-destructive testing apparatus such as concrete hammer, the development will be carried out on a different diameter core sample, which due to its small size will not affect the integrity of the structure thus Permit easy restoration of the cored surface.

Rebound Hammer Test

- This was used in combination of Destructive testing (core Cutting). Some readings were taken with rebound hammer and to check the condition of the concrete. This test was used to check the integrity and strength of the structure. The extracted core cutting sample was then tested in the laboratory thus getting the compressive strength reports in psi.

REBAR SCANNING (FERRO SCANING)

- Rebar scanning shall be performed to detect / discover the spacing, diameter and concrete cover of all reinforcement bars at selected test points for all selected structural elements of the bridge.

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CAPO TEST

- The CAPO tests are used to assess the compressive strength of concrete in structures such as concrete roads, bridges, and buildings. The CAPO test is a partially destructive technique that involves drilling a hole into the hardened concrete and inserting an oversized screw into that hole. The screw is subsequently pulled from the concrete in a manner that compels the concrete to follow a specific failure pattern.

Chloride Content, Sulphate Content, Concrete Composition & Carbonation Tests

- Chloride Content by weight of cement, Sulphate Content by weight of cement, Concrete Composition like cement content, aggregate content etc. and Carbonation Tests was performed on all extracted cores in compliance with the relevant BS standards BS 1881-124.
- The Chloride Content test on concrete was performed on the outer side of core extracted.

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PICTORIAL PROOF OF INSPECTION

1	Seepage effect and Exposed Steel

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1	Seepage effect and Exposed Steel

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1	Seepage effect and Exposed Steel

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1	Seepage effect and Exposed Steel

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2	Cracks with Exposed Steel

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2	Cracks with Exposed Steel

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2	Cracks with Exposed Steel

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NON-DESTRUCTIVE TESTING

REBOUND HAMMER TEST

The test method **ASTM C805** –**C805M-18** covers the determination of a rebound number of hardened concrete using a spring-driven steel hammer. In this test a steel hammer impacts with a predetermined amount of energy, a steel plunger in contact with a surface of concrete, and the distance that the hammer rebounds is measured.

At Jam Sadiq Bridge after conducting visual inspection of bridge F&M found out the defected areas and marking for further non-destructive testing. Rebound hammer tests were performed on the bridge to find out the average surface hardness of concrete.

This test method may be used to assess the in-place uniformity of concrete, to delineate regions in a structure of poor quality or deteriorated concrete, and to estimate in-place strength development. Because of the inherent uncertainty in the estimated strength, this test method is not intended as the basis for acceptance or rejection of concrete.

Note. Structure age can affect results from added hardness and carbonation.

Figure 1: Rebound Hammer Test

The Rebound hammer test results and markings are attached in Appendix A.

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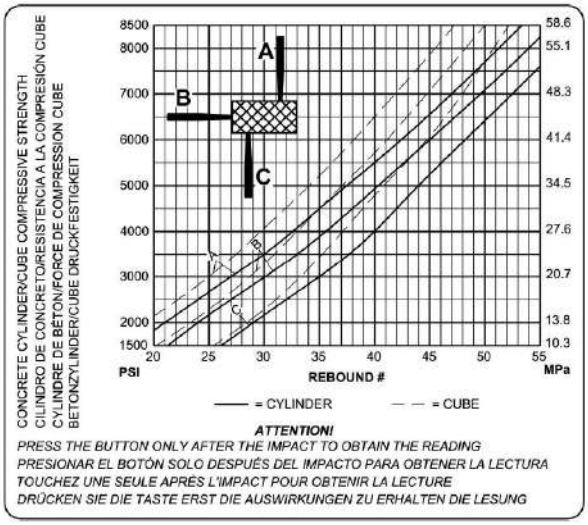

Ferro Scanning:

Ferro scan is an NDT analysis and performed on the concrete structure using state-of-the-art Hilti and Proceq equipment. This test provides information regarding steel reinforcement diameter, spacing, and concrete cover. It provides visual scan images to determine reinforcement steel details in RCC structure. **The Concrete Cover results obtained from Ferro Scanning can vary ± 10mm to 15mm.**

At Jam Sadiq Bridge after coordination and discussion with NESPAK engineers, F&M performed scanning on the given points and marking at different members of bridge to achieved further non-destructive testing.

Figure 2: Ferro Scanning

The Ferro Scanning test results and markings are attached in Appendix B.

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DESTRUCTIVE TESTING

COMPRESSIVE STRENGTH TEST THROUGH CORE RECOVERY

The test method **ASTM C42-C42M-20, ASTM C39-C39M-14, & ASTM C617-C617M-15**. Covers obtaining, preparing, and testing cores drilled from concrete for length or compressive strength determinations.

After conducting the activity of visual inspection and non-destructive testing F&M team performed the compressive strength test through core cutting and the non-destructive testing.

This test method provides standardized procedures for obtaining and testing specimens to determine the compressive.

Figure 3: Core Cutting

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The test method ASTM C42, ASTM C39, & ASTM C617. Covers determination of compressive strength of cylindrical concrete specimens such as cylinders and drilled cores. This test method consists of applying a compressive axial load to cores at a rate which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

The results of this test method are used as determination of compliance with specifications.

The Compressive Strength Test results and Markings are attached in Appendix C.

CAPO TEST

The CAPO tests are used to assess the compressive strength of concrete in structures such as concrete roads, bridges, and buildings. The CAPO test is a partially destructive technique that involves drilling a hole into the hardened concrete and inserting an oversized screw into that hole. The screw is subsequently pulled from the concrete in a manner that compels the concrete to follow a specific failure pattern.

Cut and pull out is a reliable test method to determine the compressive strength of RCC structure

Figure 4: Capo test

The Capo Test results and marking are attached in Appendix D.

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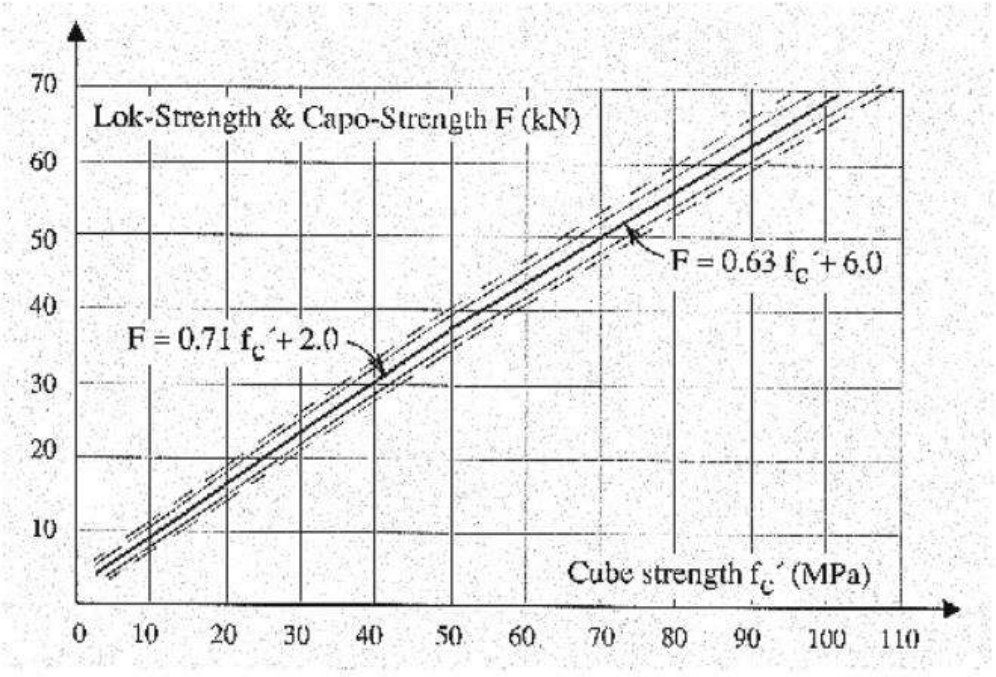

Figure 16. The suggested, general correlation between pullout strength measured by Lok-Test or Capo-Test and 150 mm standard cube compressive strength. The confidence limits are 95% limits for 16 mm (-) and 32 mm (--) maximum aggregates size (Krenchel, 1970) for an average of 2 reference tests and 4 pullouts.

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S. No.	Description	Remarks
01	**Visual Inspection**	• Seepage effect identified on deck slabs • Cracks on different member's on different location • Spalling and flacked off concrete on transom's, deck slab on all over the bridge on different locations. • Exposed steel on transom bottom, sides and corners, on deck slab different small and huge patches, and also observed on different piers. • Corrosion on steel bars. • Piers are completely covered with sewer water from grids 16 to 25 • Expansion joints are covered with debris • When heavy traffic pass from the bridge ,its start vibrating
02	**Non-Destructive Testing**	In non-destructive testing compressive strength were determined
03	**Destructive Testing**	The test method **ASTM C42, ASTM C39, & ASTM C617** and **C900-19**, destructive testing some compressive strength results in the following sections.

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CONCLUSION

Based on visual inspection, field and laboratory testing results, the following conclusions were made:

- During visual inspection major structural cracks and failures were observed on structural elements.
- Core cutting performed for destructive testing according to **ASTM C42- C42M-20, ASTM C39M & ASTM C617-C617M-15** and capo test according to **C900-19.**

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APPENDIX A – REBOUND HAMMER TEST RESULTS

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SCHMIDT HAMMER REPORT

Ref: F&M-NESPAK-JSB
Revision: 00

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS														AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER G-1(1ST)	JSB-K.K	B	52	52	56	48	58	56	56	48	48	50	52	56	56	52	52	53	7600
2	GIRDER G-1(2ND)	JSB-K.K	B	56	52	52	50	46	52	52	56	48	50	50	58	58	56	58	53	7600
3	DECK SLAB G-1(1ST)	JSB-K.K	C	48	52	48	34	50	52	50	44	48	46	48	54	50	48	50	48	5800
4	DECK SLAB G-1(2ND)	JSB-K.K	C	48	54	44	44	56	44	48	44	56	54	42	48	50	48	46	48	5800
5	DECK SLAB G-1(3RD)	JSB-K.K	C	50	50	48	52	48	44	56	42	48	52	48	46	52	46	40	48	5800
6	GRIDER G-2(1ST)	JSB-K.K	B	50	56	50	54	58	54	50	48	42	46	42	50	48	52	54	50	7000
7	GIRDER G-2(2ND)	JSB-K.K	B	52	52	58	42	50	54	48	42	52	48	48	44	56	52	50	50	7000
8	DECK SLAB G-2(1ST)	JSB-K.K	C	54	36	52	50	54	58	56	52	50	58	62	54	60	63	58	54	7300
9	DECK SLAB G-2(2ND)	JSB-K.K	C	52	48	58	52	54	52	48	50	56	50	50	54	56	52	50	52	6900
10	DECK SLAB G-2(3RD)	JSB-K.K	C	50	58	50	50	52	44	58	54	50	54	54	50	50	48	50	51	6600

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-3(1ST)	JSB-K.K	B	54	60	50	54	52	46	48	44	46	34	58	54	56	46	46	50	7000
2	GIRDER Grid-3(2ND)	JSB-K.K	B	52	58	48	52	58	58	50	54	52	48	50	38	50	52	38	50	7000
3	DECK SLAB Grid-3(1ST)	JSB-K.K	C	36	44	46	48	54	46	56	38	48	48	54	46	50	50	54	48	5800
4	DECK SLAB Grid-3(2ND)	JSB-K.K	C	48	46	40	40	48	50	46	54	52	44	48	50	48	46	52	47	5600
5	DECK SLAB Grid-3(3RD)	JSB-K.K	C	38	60	48	54	54	48	50	46	54	48	48	50	54	48	50	50	6300
6	GRIDER Grid-4(1ST)	JSB-K.K	B	46	42	58	50	44	46	48	42	46	52	50	38	50	52	44	47	6300
7	GIRDER Grid-4(2ND)	JSB-K.K	B	44	50	52	50	44	56	42	46	56	48	50	58	50	36	48	49	6700
8	DECK SLAB Grid-4(1ST)	JSB-K.K	C	46	48	48	48	50	48	48	52	50	54	48	56	44	48	50	49	6100
9	DECK SLAB Grid-4(2ND)	JSB-K.K	C	46	44	38	46	34	48	44	52	42	40	48	44	50	42	48	44	5000
10	DECK SLAB Grid-4(3RD)	JSB-K.K	C	50	42	54	38	38	58	40	46	38	54	44	38	44	32	40	44	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-5(1ST)	JSB-K.K	B	44	52	54	56	52	48	54	36	40	50	32	48	44	54	36	47	6300
2	GIRDER Grid-5(2ND)	JSB-K.K	B	58	56	56	58	54	52	54	48	56	54	54	54	50	62	50	54	8000
3	DECK SLAB Grid-5(1ST)	JSB-K.K	C	48	48	48	46	44	42	44	48	46	46	50	46	52	50	52	47	5600
4	DECK SLAB Grid-5(2ND)	JSB-K.K	C	52	46	52	42	50	46	50	42	44	54	42	48	52	42	42	47	5600
5	DECK SLAB Grid-5(3RD)	JSB-K.K	C	56	40	40	48	42	44	42	52	52	46	42	54	46	50	42	46	5400
6	GRIDER Grid-6(1ST)	JSB-K.K	B	56	48	48	46	52	56	52	48	46	50	58	50	52	50	52	51	7200
7	GIRDER Grid-6(2ND)	JSB-K.K	B	50	52	50	48	48	50	50	54	48	56	54	54	52	52	52	51	7200
8	DECK SLAB Grid-6(1ST)	JSB-K.K	C	56	52	50	50	48	56	52	52	48	46	50	58	50	52	50	51	6600
9	DECK SLAB Grid-6(2ND)	JSB-K.K	C	52	50	52	52	56	52	54	48	50	50	56	50	52	52	48	52	6900
10	DECK SLAB Grid-6(3RD)	JSB-K.K	C	48	46	48	58	52	48	54	54	50	54	52	52	48	50	50	51	6600

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-7(1ST)	JSB-K.K	B	50	50	48	52	50	50	56	48	56	52	50	56	54	52	52	52	7500
2	GIRDER Grid-7(2ND)	JSB-K.K	B	48	56	56	50	48	56	52	52	50	52	54	50	48	50	52	52	7500
3	DECK SLAB Grid-7(1ST)	JSB-K.K	C	52	46	50	44	40	52	46	50	46	52	50	50	56	50	46	49	6100
4	DECK SLAB Grid-7(2ND)	JSB-K.K	C	50	56	56	52	48	56	50	48	50	50	52	50	48	52	50	51	6600
5	DECK SLAB Grid-7(3RD)	JSB-K.K	C	56	48	52	52	56	50	46	52	50	58	52	52	50	50	54	52	6900
6	GRIDER Grid-8(1ST)	JSB-K.K	B	50	54	50	56	58	58	56	50	48	50	54	54	56	56	52	53	7600
7	GIRDER Grid-8(2ND)	JSB-K.K	B	56	54	56	56	58	50	50	52	52	50	50	58	54	56	42	53	7600
8	DECK SLAB Grid-8(1ST)	JSB-K.K	C	44	48	44	42	40	42	40	42	50	54	44	46	50	52	50	46	5400
9	DECK SLAB Grid-8(2ND)	JSB-K.K	C	50	46	42	50	54	48	42	42	52	56	50	48	42	42	50	48	5800
10	DECK SLAB Grid-8(3RD)	JSB-K.K	C	48	50	50	48	56	48	42	52	52	42	50	44	50	44	48	48	5800

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-9(1ST)	JSB-K.K	B	56	52	52	50	50	56	54	40	52	50	58	54	50	50	54	52	7500
2	GIRDER Grid-9(2ND)	JSB-K.K	B	58	54	54	50	52	48	50	50	54	50	56	54	56	48	52	52	7500
3	DECK SLAB Grid-9(1ST)	JSB-K.K	C	52	52	46	50	50	50	54	48	56	50	50	56	50	48	46	50	6300
4	DECK SLAB Grid-9(2ND)	JSB-K.K	C	50	56	52	52	52	56	50	50	48	56	56	50	50	56	56	53	7100
5	DECK SLAB Grid-9(3RD)	JSB-K.K	C	48	58	48	56	58	52	50	50	48	52	56	48	52	48	50	52	6900
6	GRIDER Grid-10(1ST)	JSB-K.K	B	58	54	54	56	46	58	56	56	42	54	54	56	58	60	54	54	8000
7	GIRDER Grid-10(2ND)	JSB-K.K	B	48	56	54	60	48	44	42	54	52	58	56	54	50	48	42	51	7200
8	DECK SLAB Grid-10(1ST)	JSB-K.K	C	56	56	48	60	52	54	60	52	56	56	44	48	48	58	52	53	7100
9	DECK SLAB Grid-10(2ND)	JSB-K.K	C	58	48	60	58	48	48	44	52	46	56	54	50	60	48	56	52	6900
10	DECK SLAB Grid-10(3RD)	JSB-K.K	C	52	56	50	56	50	50	60	50	50	56	56	52	52	56	54	53	7100

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

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1	GRIDER Grid-11(1ST)	JSB-K.K	B	56	58	52	60	52	46	44	50	54	60	52	54	50	50	48	52	7500
2	GIRDER Grid-11(2ND)	JSB-K.K	B	42	48	56	48	40	56	54	48	56	52	52	50	48	46	40	50	7000
3	DECK SLAB Grid-11(1ST)	JSB-K.K	C	54	48	54	50	52	56	56	58	54	60	52	58	56	52	50	54	7300
4	DECK SLAB Grid-11(2ND)	JSB-K.K	C	54	48	52	46	44	46	56	50	52	52	48	54	58	56	56	51	6600
5	DECK SLAB Grid-11(3RD)	JSB-K.K	C	58	52	50	50	58	54	52	58	48	50	54	48	54	58	50	53	7100
6	GRIDER Grid-12(1ST)	JSB-K.K	B	54	60	50	44	64	48	56	54	40	48	54	56	50	56	54	53	7600
7	GIRDER Grid-12(2ND)	JSB-K.K	B	50	50	46	52	50	50	48	50	48	40	58	60	52	52	60	51	7200
8	DECK SLAB Grid-12(1ST)	JSB-K.K	C	58	52	50	50	54	54	48	56	54	54	50	52	60	32	38	51	6600
9	DECK SLAB Grid-12(2ND)	JSB-K.K	C	48	54	50	58	56	52	56	50	54	54	50	52	52	50	52	53	7100
10	DECK SLAB Grid-12(3RD)	JSB-K.K	C	52	56	58	56	52	50	50	54	54	50	52	52	52	50	48	52	6900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-13(1ST)	JSB-K.K	B	52	52	50	50	54	52	50	52	56	50	50	46	58	52	50	52	7500
2	GIRDER Grid-13(2ND)	JSB-K.K	B	56	50	48	58	52	50	54	58	50	56	48	56	52	50	52	52	7500
3	DECK SLAB Grid-13(1ST)	JSB-K.K	C	54	48	56	58	54	54	52	56	54	54	54	50	58	50	52	54	7300
4	DECK SLAB Grid-13(2ND)	JSB-K.K	C	52	58	56	50	52	48	54	52	56	50	52	52	54	56	52	53	7100
5	DECK SLAB Grid-13(3RD)	JSB-K.K	C	50	56	50	52	48	60	52	56	52	56	52	52	56	48	58	53	7100
6	GRIDER Grid-14(1ST)	JSB-K.K	B	54	52	52	50	48	54	58	40	48	56	50	52	56	54	50	52	7500
7	GIRDER Grid-14(2ND)	JSB-K.K	B	44	46	48	50	50	54	54	50	56	52	56	48	52	54	50	51	7200
8	DECK SLAB Grid-14(1ST)	JSB-K.K	C	52	52	58	48	54	54	56	54	58	54	48	50	54	50	50	53	7100
9	DECK SLAB Grid-14(2ND)	JSB-K.K	C	58	52	58	54	48	50	58	56	52	54	50	54	56	50	54	54	7300
10	DECK SLAB Grid-14(3RD)	JSB-K.K	C	48	60	50	56	52	58	56	54	50	52	56	54	50	52	48	53	7100

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-15(1ST)	JSB-K.K	B	50	50	50	48	48	54	56	52	50	52	52	52	50	54	50	51	7200
2	GIRDER Grid-15(2ND)	JSB-K.K	B	48	44	52	52	50	56	54	50	56	56	46	52	56	50	52	52	7500
3	DECK SLAB Grid-15(1ST)	JSB-K.K	C	50	54	50	48	52	50	52	52	50	58	54	54	50	52	48	51	6600
4	DECK SLAB Grid-15(2ND)	JSB-K.K	C	54	56	52	52	48	48	52	50	58	52	52	50	52	58	52	52	6900
5	DECK SLAB Grid-15(3RD)	JSB-K.K	C	58	50	50	52	50	56	50	48	50	52	50	52	50	50	56	52	6900
6	GRIDER Grid-16(1ST)	JSB-K.K	B	52	52	48	56	48	52	54	52	54	52	56	48	54	52	52	52	7500
7	GIRDER Grid-16(2ND)	JSB-K.K	B	56	56	50	52	50	52	50	56	54	50	50	48	54	54	48	52	7500
8	DECK SLAB Grid-16(1ST)	JSB-K.K	C	50	56	52	46	50	48	56	56	52	50	52	50	58	50	54	52	6900
9	DECK SLAB Grid-16(2ND)	JSB-K.K	C	56	50	50	48	50	54	50	58	54	48	54	52	52	50	56	52	6900
10	DECK SLAB Grid-16(3RD)	JSB-K.K	C	56	48	52	48	54	56	50	50	52	48	54	50	58	54	46	52	6900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS																AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-26(1ST)	JSB-K.K	B	50	50	56	48	52	50	50	48	52	56	46	52	46	52	48		50	7000
2	GIRDER Grid-26(2ND)	JSB-K.K	B	52	54	54	52	52	56	52	48	48	50	52	48	52	46	52		51	7200
3	DECK SLAB Grid-26(1ST)	JSB-K.K	C	56	48	52	52	50	54	48	50	50	46	54	46	50	54	48		51	6600
4	DECK SLAB Grid-26(2ND)	JSB-K.K	C	54	54	52	56	54	54	50	52	50	50	54	50	56	52	48		52	6900
5	DECK SLAB Grid-26(3RD)	JSB-K.K	C	54	50	52	54	50	52	54	46	52	56	50	50	48	56	56		52	6900
6	GRIDER Grid-27(1ST)	JSB-K.K	B	48	54	48	50	50	52	48	52	56	54	56	50	50	52	50		51	7200
7	GIRDER Grid-27(2ND)	JSB-K.K	B	50	52	50	52	56	50	52	48	52	48	50	48	56	54	50		51	7200
8	DECK SLAB Grid-27(1ST)	JSB-K.K	C	54	58	50	50	48	52	56	52	48	50	54	54	50	48	50		52	6900
9	DECK SLAB Grid-27(2ND)	JSB-K.K	C	56	50	50	56	54	50	50	50	54	56	46	50	52	50	48		51	6600
10	DECK SLAB Grid-27(3RD)	JSB-K.K	C	50	58	50	52	50	56	54	52	54	52	56	48	48	52	50		52	6900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
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S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-28(1ST)	JSB-K.K	B	50	54	50	48	48	52	52	50	52	50	50	56	46	48	50	50	7000
2	GIRDER Grid-28(2ND)	JSB-K.K	B	52	52	52	58	54	54	50	52	50	56	52	52	50	50	48	52	7500
3	DECK SLAB Grid-28(1ST)	JSB-K.K	C	56	54	56	50	50	48	44	56	56	50	54	56	50	54	50	52	6900
4	DECK SLAB Grid-28(2ND)	JSB-K.K	C	50	58	50	48	56	52	52	58	50	48	48	50	56	48	48	52	6900
5	DECK SLAB Grid-28(3RD)	JSB-K.K	C	54	54	48	50	50	48	50	54	50	50	52	50	52	50	56	51	6600
6	GRIDER Grid-29(1ST)	JSB-K.K	B	46	52	50	58	48	56	50	48	52	52	54	52	52	54	54	52	7500
7	GIRDER Grid-29(2ND)	JSB-K.K	B	52	56	52	44	52	52	50	58	54	52	50	52	56	50	48	52	7500
8	DECK SLAB Grid-29(1ST)	JSB-K.K	C	50	50	56	54	54	52	58	50	54	52	52	50	50	54	56	53	7100
9	DECK SLAB Grid-29(2ND)	JSB-K.K	C	48	52	58	48	52	52	56	48	52	50	52	54	50	52	50	52	6900
10	DECK SLAB Grid-29(3RD)	JSB-K.K	C	50	58	56	58	52	56	50	48	48	46	50	56	52	54	50	52	6900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-30(1ST)	JSB-K.K	B	46	52	56	42	54	52	48	50	54	54	52	52	48	46	50	51	7200
2	GIRDER Grid-30(2ND)	JSB-K.K	B	38	40	46	44	44	48	50	46	48	52	52	50	56	50	48	48	6500
3	DECK SLAB Grid-30(1ST)	JSB-K.K	C	54	56	44	60	54	52	56	52	52	56	50	54	50	50	56	53	7100
4	DECK SLAB Grid-30(2ND)	JSB-K.K	C	56	52	52	48	52	58	50	52	52	48	56	52	58	54	56	53	7100
5	DECK SLAB Grid-30(3RD)	JSB-K.K	C	52	52	58	52	56	56	50	50	52	52	48	50	50	58	54	53	7100
6	GRIDER Grid-31(1ST)	JSB-K.K	B	52	52	54	52	48	52	56	50	52	48	50	48	56	54	48	51	7200
7	GIRDER Grid-31(2ND)	JSB-K.K	B	56	56	54	56	50	44	58	52	56	48	52	50	48	52	46	52	7500
8	DECK SLAB Grid-31(1ST)	JSB-K.K	C	52	50	50	52	50	48	50	52	50	54	52	56	52	50	50	51	6600
9	DECK SLAB Grid-31(2ND)	JSB-K.K	C	56	56	52	54	52	56	50	50	46	46	58	54	48	50	48	52	6900
10	DECK SLAB Grid-31(3RD)	JSB-K.K	C	52	48	52	48	48	54	50	58	52	58	52	52	50	52	56	52	6900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-32(1ST)	JSB-K.K	B	50	42	42	42	48	48	42	42	50	48	48	42	42	42	48	45	5700
2	GIRDER Grid-32(2ND)	JSB-K.K	B	48	42	48	46	46	42	42	50	48	48	50	42	48	48	50	46	6000
3	DECK SLAB Grid-32(1ST)	JSB-K.K	C	50	51	50	56	48	52	50	54	54	52	50	48	46	50	48	51	6600
4	DECK SLAB Grid-32(2ND)	JSB-K.K	C	56	50	54	54	50	52	48	50	46	52	52	58	50	48	46	51	6600
5	DECK SLAB Grid-32(3RD)	JSB-K.K	C	52	58	50	50	48	52	54	56	56	50	48	46	48	50	52	51	6600
6	GRIDER Grid-33(1ST)	JSB-K.K	B	48	50	42	42	46	44	42	48	50	48	42	44	48	42	42	45	6000
7	GIRDER Grid-33(2ND)	JSB-K.K	B	46	46	42	42	50	48	44	48	44	42	42	44	48	46	42	45	6000
8	DECK SLAB Grid-33(1ST)	JSB-K.K	C	50	56	52	52	56	54	54	52	50	56	54	56	52	54	50	53	7100
9	DECK SLAB Grid-33(2ND)	JSB-K.K	C	56	56	56	50	54	50	54	54	52	52	56	54	52	52	50	53	7100
10	DECK SLAB Grid-33(3RD)	JSB-K.K	C	52	56	52	52	56	54	54	50	54	56	50	52	52	56	52	53	7100

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS																AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-34(1ST)	JSB-K.K	B	46	50	46	40	46	48	48	50	52	52	44	48	48	52	42		48	6500
2	GIRDER Grid-34(2ND)	JSB-K.K	B	50	46	46	50	48	50	52	52	44	40	44	40	40	48	52		47	6300
3	DECK SLAB Grid-34(1ST)	JSB-K.K	C	50	56	54	52	54	54	52	52	50	56	54	54	48	50	50		52	6900
4	DECK SLAB Grid-34(2ND)	JSB-K.K	C	56	48	54	54	48	56	56	52	56	50	50	54	50	52	48		52	6900
5	DECK SLAB Grid-34(3RD)	JSB-K.K	C	54	54	52	54	50	48	56	52	52	50	48	56	52	52	54		52	6900
6	GRIDER Grid-35(1ST)	JSB-K.K	B	42	40	38	50	44	40	50	42	42	50	48	40	48	40	44		44	5700
7	GIRDER Grid-35(2ND)	JSB-K.K	B	40	50	44	46	50	52	52	44	40	40	48	52	48	46	48		47	6300
8	DECK SLAB Grid-35(1ST)	JSB-K.K	C	54	50	54	56	52	52	50	52	54	56	52	52	50	56	50		53	7100
9	DECK SLAB Grid-35(2ND)	JSB-K.K	C	52	56	50	54	54	48	50	56	56	50	46	56	50	52	52		52	6900
10	DECK SLAB Grid-35(3RD)	JSB-K.K	C	50	54	54	52	56	56	50	56	56	48	48	56	56	50	50		53	7100

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	GRIDER Grid-36(1ST)	JSB-K.K	B	40	46	38	40	48	40	38	50	46	44	52	50	48	40	46	45	6000
2	GIRDER Grid-36(2ND)	JSB-K.K	B	48	50	42	42	46	48	52	50	44	46	40	50	38	46	44	46	6100
3	DECK SLAB Grid-36(1ST)	JSB-K.K	C	52	50	54	52	56	52	48	56	54	56	52	52	48	54	52	53	7100
4	DECK SLAB Grid-36(2ND)	JSB-K.K	C	50	56	56	52	56	50	50	54	48	52	50	50	52	52	50	52	6900
5	DECK SLAB Grid-36(3RD)	JSB-K.K	C	56	56	48	50	50	54	54	48	52	50	48	50	56	56	48	52	6900
6	GRIDER Grid-37(1ST)	JSB-K.K	B	44	40	46	42	48	50	32	42	40	48	40	44	42	50	48	44	5700
7	GIRDER Grid-37(2ND)	JSB-K.K	B	34	38	34	38	30	34	42	38	40	44	42	36	48	40	44	39	4700
8	DECK SLAB Grid-37(1ST)	JSB-K.K	C	50	48	56	58	50	48	54	58	56	56	58	50	58	60	58	55	7500
9	DECK SLAB Grid-37(2ND)	JSB-K.K	C	48	52	56	52	52	48	58	50	50	56	52	54	50	48	52	52	6900
10	DECK SLAB Grid-37(3RD)	JSB-K.K	C	48	56	56	54	56	52	52	48	58	58	52	52	56	58	52	54	7300

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	25/10/2021	8/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	Transom 1 (01)	JSB-K.K	0°	46	38	40	46	50	40	50	42	48	38	36	40	42	42	42	43	5500
2	Transom 1 (02)	JSB-K.K	0°	42	46	44	44	38	40	38	46	42	46	38	40	38	46	40	42	5200
3	Transom 1 (03)	JSB-K.K	0°	42	40	42	38	38	44	40	38	44	40	50	42	40	38	36	41	5000
4	Transom 1 (04)	JSB-K.K	0°	42	42	38	46	40	40	42	36	36	44	42	40	44	42	40	41	5000
5	Transom 2 (01)	JSB-K.K	0°	42	40	40	42	46	42	50	40	38	38	46	36	42	34	32	41	5000
6	Transom 2 (02)	JSB-K.K	0°	46	48	30	42	34	40	42	44	32	32	36	38	38	36	42	39	4700
7	Transom 2 (03)	JSB-K.K	0°	40	42	42	38	38	42	44	38	40	40	36	40	44	36	40	40	4900
8	Transom 2 (04)	JSB-K.K	0°	36	40	36	42	38	44	44	32	38	38	42	38	46	40	40	40	4900
9	Transom 3 (01)	JSB-K.K	0°	50	36	40	38	46	40	36	30	40	48	34	52	32	50	46	41	5000
10	Transom 3 (02)	JSB-K.K	0°	42	38	44	32	48	50	34	36	42	44	48	52	44	32	44	42	5200
11	Transom 3 (03)	JSB-K.K	0°	46	32	44	30	38	40	44	48	46	44	38	44	50	50	46	42	5200
12	Transom 3 (04)	JSB-K.K	0°	38	38	42	42	40	44	42	54	50	48	38	38	38	36	36	42	5200
13	Transom 4 (01)	JSB-K.K	0°	42	42	36	44	44	32	40	36	40	42	38	44	38	50	36	40	4900
14	Transom 4 (02)	JSB-K.K	0°	46	42	40	46	42	36	30	42	38	40	38	42	38	38	32	39	4700
15	Transom 4 (03)	JSB-K.K	0°	40	42	40	46	42	40	38	38	36	40	42	38	36	36	38	39	4700
16	Transom 4 (04)	JSB-K.K	0°	38	36	40	40	42	44	42	42	48	44	48	38	42	44	42	42	5200

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
17	Transom 5 (01)	JSB-K.K	0°	40	44	40	36	34	40	40	28	32	42	40	44	34	36	30	37	4200
18	Transom 5 (02)	JSB-K.K	0°	40	42	34	40	34	44	32	42	44	40	44	34	40	36	44	39	4700
19	Transom 5 (03)	JSB-K.K	0°	40	42	34	40	48	44	32	42	44	40	44	48	40	36	44	41	5000
20	Transom 5 (04)	JSB-K.K	0°	42	44	40	44	40	36	46	36	34	34	42	42	42	40	41	40	4900
21	Transom 6 (01)	JSB-K.K	0°	40	40	42	40	44	38	40	44	40	48	46	38	42	40	44	42	5200
22	Transom 6 (02)	JSB-K.K	0°	44	40	48	44	42	42	44	38	38	36	40	42	44	40	38	41	5000
23	Transom 6 (03)	JSB-K.K	0°	44	38	44	36	40	40	34	46	40	36	44	40	40	42	40	40	4900
24	Transom 6 (04)	JSB-K.K	0°	36	38	36	38	40	44	44	42	48	46	46	42	38	38	36	41	5000
25	Transom 7 (01)	JSB-K.K	0°	56	52	48	50	48	46	50	38	38	48	46	44	46	40	52	46	6100
26	Transom 7 (02)	JSB-K.K	0°	42	54	52	46	52	50	48	46	38	44	40	42	40	44	40	45	6000
27	Transom 7 (03)	JSB-K.K	0°	40	42	46	46	44	42	50	46	38	38	36	42	40	44	42	43	5500
28	Transom 7 (04)	JSB-K.K	0°	52	46	46	45	42	40	42	40	38	38	36	40	40	42	44	41	5000
29	Transom 8 (01)	JSB-K.K	0°	42	42	38	40	40	44	38	38	44	36	48	36	44	40	42	41	5000
30	Transom 8 (02)	JSB-K.K	0°	44	40	44	40	40	36	40	44	48	36	42	44	40	40	41	41	5000
31	Transom 8 (03)	JSB-K.K	0°	36	40	40	44	40	36	38	32	40	42	44	42	40	42	42	40	4900
32	Transom 8 (04)	JSB-K.K	0°	36	36	38	40	44	42	44	40	42	38	38	34	34	38	40	39	4700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
33	Transom 9 (01)	JSB-K.K	0°	38	42	38	40	40	36	44	42	46	40	40	38	44	36	42	40	4900
34	Transom 9 (02)	JSB-K.K	0°	42	36	38	42	40	40	36	44	40	32	46	40	44	40	40	40	4900
35	Transom 9 (03)	JSB-K.K	0°	46	42	42	40	40	38	36	40	32	36	40	36	40	40	44	39	4700
36	Transom 9 (04)	JSB-K.K	0°	42	46	46	38	38	36	40	36	40	42	46	42	38	38	44	41	5000
37	Transom 10 (01)	JSB-K.K	0°	42	42	44	42	36	42	42	40	38	42	40	42	38	40	40	41	5000
38	Transom 10 (02)	JSB-K.K	0°	38	34	38	34	38	36	36	34	38	38	34	38	34	36	36	36	4000
39	Transom 10 (03)	JSB-K.K	0°	42	44	42	40	40	46	38	36	32	32	34	40	42	42	40	39	4700
40	Transom 10 (04)	JSB-K.K	0°	42	38	38	40	40	42	42	38	38	46	50	52	40	36	32	41	5000
41	Transom 11 (01)	JSB-K.K	0°	52	48	46	48	46	44	40	54	44	40	40	40	44	40	46	44	5700
42	Transom 11 (02)	JSB-K.K	0°	44	42	40	44	40	42	38	36	36	40	40	44	48	38	40	41	5000
43	Transom 11 (03)	JSB-K.K	0°	44	46	40	42	38	42	40	44	36	42	44	36	44	40	42	41	5000
44	Transom 11 (04)	JSB-K.K	0°	39	38	44	40	44	42	46	38	36	38	40	44	36	44	40	41	5000
45	Transom 12 (01)	JSB-K.K	0°	46	44	48	38	40	48	50	42	40	34	40	40	38	42	46	42	5200
46	Transom 12 (02)	JSB-K.K	0°	40	42	40	44	46	38	38	36	34	34	36	40	44	42	44	40	4900
47	Transom 12 (03)	JSB-K.K	0°	40	38	42	44	46	52	30	44	46	44	44	34	40	38	50	42	5200
48	Transom 12 (04)	JSB-K.K	0°	36	40	40	44	42	44	38	38	36	38	40	42	46	46	38	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS														AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
49	Transom 13 (01)	JSB-K.K	0°	44	52	48	52	40	44	42	40	46	48	42	38	42	40	40	43	5500
50	Transom 13 (02)	JSB-K.K	0°	42	44	42	44	40	40	38	36	40	46	50	46	52	38	38	42	5200
51	Transom 13 (03)	JSB-K.K	0°	34	42	36	40	36	40	44	42	32	34	40	44	38	40	42	39	4700
52	Transom 13 (04)	JSB-K.K	0°	44	40	36	34	34	40	44	42	34	40	42	46	36	38	32	38	4500
53	Transom 14 (01)	JSB-K.K	0°	48	50	44	50	44	46	42	40	48	44	38	42	46	40	42	44	5700
54	Transom 14 (02)	JSB-K.K	0°	50	50	52	40	44	46	38	42	42	44	38	36	46	44	40	43	5500
55	Transom 14 (03)	JSB-K.K	0°	48	42	44	52	46	50	42	48	50	46	44	42	44	40	46	46	6100
56	Transom 14 (04)	JSB-K.K	0°	42	44	42	50	48	42	46	50	42	48	38	40	44	48	42	45	6000
57	Transom 15 (01)	JSB-K.K	0°	46	50	42	42	40	46	38	40	42	44	42	40	42	46	40	42	5200
58	Transom 15 (02)	JSB-K.K	0°	42	42	48	46	38	50	36	40	44	42	43	48	50	44	34	43	5500
59	Transom 15 (03)	JSB-K.K	0°	42	40	46	42	42	40	50	52	40	42	40	40	46	50	38	43	5500
60	Transom 15 (04)	JSB-K.K	0°	36	38	40	44	42	50	42	34	38	38	40	44	46	42	40	41	5000
61	Transom 16 (01)	JSB-K.K	0°	42	50	42	42	40	40	42	42	44	38	40	40	46	42	40	42	5200
62	Transom 16 (02)	JSB-K.K	0°	50	48	44	44	40	38	42	42	44	48	38	36	40	40	42	42	5200
63	Transom 16 (03)	JSB-K.K	0°	44	42	44	44	40	40	42	38	40	40	44	40	36	40	46	41	5000
64	Transom 16 (04)	JSB-K.K	0°	48	44	38	38	36	40	40	40	42	46	44	38	36	40	40	40	4900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
65	Transom 17 (01)	JSB-K.K	0°	42	40	42	38	42	46	40	42	38	40	46	40	36	44	40	41	5000
66	Transom 17 (02)	JSB-K.K	0°	40	46	40	44	42	40	42	40	40	32	40	44	42	42	38	41	5000
67	Transom 17 (03)	JSB-K.K	0°	44	38	40	44	36	36	46	48	46	38	42	40	40	38	40	41	5000
68	Transom 17 (04)	JSB-K.K	0°	38	36	40	44	48	44	46	36	40	38	38	40	42	44	42	41	5000
69	Transom 18 (01)	JSB-K.K	0°	40	38	38	42	46	44	38	30	48	42	38	44	42	42	34	40	4900
70	Transom 18 (02)	JSB-K.K	0°	44	36	42	48	40	50	48	46	42	38	40	38	38	40	46	42	5200
71	Transom 18 (03)	JSB-K.K	0°	40	48	48	44	40	42	38	38	36	40	40	41	48	44	40	42	5200
72	Transom 18 (04)	JSB-K.K	0°	36	36	38	40	38	44	42	42	42	44	48	46	38	38	40	41	5000
73	Transom 19 (01)	JSB-K.K	0°	40	46	50	42	40	50	40	44	52	46	40	32	38	40	40	43	5500
74	Transom 19 (02)	JSB-K.K	0°	48	42	44	46	40	50	42	40	52	46	42	42	30	46	42	43	5500
75	Transom 19 (03)	JSB-K.K	0°	40	40	42	44	48	46	50	44	38	38	39	40	44	40	40	42	5200
76	Transom 19 (04)	JSB-K.K	0°	38	38	38	44	42	46	46	38	42	40	40	50	52	44	40	43	5500
77	Transom 20 (01)	JSB-K.K	0°	50	48	44	42	52	40	48	46	50	44	40	48	40	46	40	45	6000
78	Transom 20 (02)	JSB-K.K	0°	40	40	46	42	44	48	44	48	38	42	40	46	40	48	46	44	5700
79	Transom 20 (03)	JSB-K.K	0°	50	48	48	46	40	50	38	40	44	42	46	40	38	38	40	43	5500
80	Transom 20 (04)	JSB-K.K	0°	45	44	40	44	48	48	50	38	38	42	40	40	38	40	44	42	5200

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
81	Transom 21 (01)	JSB-K.K	0°	40	38	44	40	46	42	38	48	46	38	40	38	42	40	40	42	5200
82	Transom 21 (02)	JSB-K.K	0°	48	38	34	30	36	42	42	46	42	40	36	40	36	42	40	39	4700
83	Transom 21 (03)	JSB-K.K	0°	40	42	42	44	48	36	36	38	40	44	40	40	38	46	36	41	5000
84	Transom 21 (04)	JSB-K.K	0°	38	38	34	40	44	44	48	50	48	44	40	48	36	38	40	42	5200
85	Transom 22 (01)	JSB-K.K	0°	42	38	40	40	44	42	42	44	38	40	36	42	46	38	46	41	5000
86	Transom 22 (02)	JSB-K.K	0°	44	40	40	46	40	42	48	46	48	48	48	30	42	42	40	43	5500
87	Transom 22 (03)	JSB-K.K	0°	40	44	48	48	40	38	38	36	44	40	44	48	48	42	40	43	5500
88	Transom 22 (04)	JSB-K.K	0°	38	36	40	40	44	42	48	48	46	50	48	38	36	40	40	43	5500
89	Transom 23 (01)	JSB-K.K	0°	42	40	32	44	42	48	44	34	38	40	40	40	36	40	46	40	4900
90	Transom 23 (02)	JSB-K.K	0°	42	32	38	42	42	34	38	40	40	34	36	40	48	38	40	39	4700
91	Transom 23 (03)	JSB-K.K	0°	38	32	42	44	48	46	44	48	42	38	36	44	42	46	46	43	5500
92	Transom 23 (04)	JSB-K.K	0°	32	40	42	42	42	44	48	38	36	44	42	40	40	42	46	42	5200
93	Transom 24 (01)	JSB-K.K	0°	44	40	44	42	42	50	48	44	38	50	44	40	40	42	40	43	5500
94	Transom 24 (02)	JSB-K.K	0°	46	46	44	48	46	48	54	50	48	40	38	50	40	38	44	45	6000
95	Transom 24 (03)	JSB-K.K	0°	48	50	48	46	44	46	38	36	40	40	44	42	38	44	40	43	5500
96	Transom 24 (04)	JSB-K.K	0°	50	48	48	46	44	42	44	40	40	40	48	50	46	40	40	44	5700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
97	Transom 25 (01)	JSB-K.K	0°	46	48	50	38	46	38	40	44	48	40	40	44	32	44	38	42	5200
98	Transom 25 (02)	JSB-K.K	0°	42	40	42	54	48	40	42	46	42	40	44	46	44	40	40	43	5500
99	Transom 25 (03)	JSB-K.K	0°	40	42	42	44	48	44	40	44	38	44	46	50	52	40	38	44	5700
100	Transom 25 (04)	JSB-K.K	0°	38	40	44	42	44	40	40	38	44	32	36	48	40	42	44	41	5000
101	Transom 26 (01)	JSB-K.K	0°	44	40	44	46	38	40	38	38	42	42	44	44	46	38	38	41	5000
102	Transom 26 (02)	JSB-K.K	0°	40	40	46	38	38	42	42	48	50	48	42	46	38	40	46	43	5500
103	Transom 26 (03)	JSB-K.K	0°	46	44	40	40	38	50	40	34	44	42	40	42	48	40	38	42	5200
104	Transom 26 (04)	JSB-K.K	0°	50	52	44	46	42	40	40	38	36	32	44	42	48	50	40	42	5200
105	Transom 27 (01)	JSB-K.K	0°	48	52	46	48	38	36	44	44	46	42	40	54	48	50	48	45	6000
106	Transom 27 (02)	JSB-K.K	0°	54	48	48	44	40	52	44	44	36	44	52	46	46	40	40	45	6000
107	Transom 27 (03)	JSB-K.K	0°	44	46	46	42	48	50	38	36	40	44	42	45	44	40	40	43	5500
108	Transom 27 (04)	JSB-K.K	0°	52	50	38	36	44	40	42	42	48	38	40	48	36	42	44	42	5200
109	Transom 28 (01)	JSB-K.K	0°	38	42	44	30	38	40	44	36	32	38	36	48	40	44	38	39	4700
110	Transom 28 (02)	JSB-K.K	0°	40	38	34	40	42	38	46	40	44	42	30	34	36	38	34	38	4500
111	Transom 28 (03)	JSB-K.K	0°	44	42	42	46	38	40	42	50	38	52	44	40	42	36	32	42	5200
112	Transom 28 (04)	JSB-K.K	0°	50	48	48	44	46	38	46	44	38	40	50	48	44	42	42	44	5700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
113	Transom 29 (01)	JSB-K.K	0°	40	42	42	42	44	42	38	40	40	40	40	44	44	40	34	41	5000
114	Transom 29 (02)	JSB-K.K	0°	28	30	30	32	34	32	38	32	32	36	38	28	32	38	40	34	3700
115	Transom 29 (03)	JSB-K.K	0°	32	32	30	38	40	32	38	44	40	42	44	40	32	36	38	38	4500
116	Transom 29 (04)	JSB-K.K	0°	40	32	32	36	40	42	44	38	32	32	36	28	44	42	40	37	4200
117	Transom 30 (01)	JSB-K.K	0°	46	52	42	48	46	46	52	48	48	52	40	42	44	44	52	47	6300
118	Transom 30 (02)	JSB-K.K	0°	38	40	42	34	52	44	36	40	48	50	42	40	36	46	48	42	5200
119	Transom 30 (03)	JSB-K.K	0°	40	44	42	40	38	36	32	33	42	40	40	50	52	44	48	41	5000
120	Transom 30 (04)	JSB-K.K	0°	44	46	48	38	36	38	40	40	40	42	44	42	44	38	42	41	5000
121	Transom 31 (01)	JSB-K.K	0°	40	40	48	46	50	38	38	40	46	46	44	40	44	38	40	43	5500
122	Transom 31 (02)	JSB-K.K	0°	46	40	40	46	40	38	48	48	50	46	40	40	40	46	40	43	5500
123	Transom 31 (03)	JSB-K.K	0°	48	44	42	40	40	44	42	38	40	36	32	44	42	40	48	41	5000
124	Transom 31 (04)	JSB-K.K	0°	42	42	44	38	46	48	38	48	38	44	40	40	44	38	42	42	5200
125	Transom 32 (01)	JSB-K.K	0°	36	40	38	40	44	40	42	40	38	40	40	44	36	40	40	40	4900
126	Transom 32 (02)	JSB-K.K	0°	46	40	40	38	40	38	44	38	46	40	36	38	44	38	44	40	4900
127	Transom 32 (03)	JSB-K.K	0°	44	42	40	40	38	42	44	38	36	40	35	38	44	42	48	41	5000
128	Transom 32 (04)	JSB-K.K	0°	40	42	42	44	38	44	32	40	42	44	38	34	42	44	44	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS														AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
129	Transom 33 (01)	JSB-K.K	-90°																
130	Transom 33 (02)	JSB-K.K	-90°																
131	Transom 33 (03)	JSB-K.K	-90°																
132	Transom 33 (04)	JSB-K.K	-90°																
133	Transom 34 (01)	JSB-K.K	-90°	42	40	44	48	50	48	44	46	42	42	40	40	42	44	38	43	5500
134	Transom 34 (02)	JSB-K.K	-90°	34	38	36	44	42	44	40	46	48	42	38	36	36	42	44	41	5000
135	Transom 34 (03)	JSB-K.K	-90°	32	40	44	48	44	42	48	50	52	48	38	34	36	40	44	43	5500
136	Transom 34 (04)	JSB-K.K	-90°	42	42	44	46	46	44	42	48	38	32	38	40	40	44	42	42	5200
137	Transom 35 (01)	JSB-K.K	-90°	40	42	44	34	42	40	46	34	46	40	44	36	32	40	34	40	4900
138	Transom 35 (02)	JSB-K.K	-90°	40	38	34	36	40	38	32	34	36	40	34	34	38	36	40	36	4000
139	Transom 35 (03)	JSB-K.K	-90°	32	46	44	42	44	40	40	42	48	38	38	36	44	42	46	42	5200
140	Transom 35 (04)	JSB-K.K	-90°	40	42	40	42	38	38	42	50	50	52	38	38	42	44	48	43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
141	Transom 36 (01)	JSB-K.K	0°	38	36	30	42	42	42	34	40	38	40	38	32	42	36	38	38	4500
142	Transom 36 (02)	JSB-K.K	0°	36	34	28	38	40	28	32	30	32	40	34	34	40	34	36	34	3700
143	Transom 36 (03)	JSB-K.K	0°	34	38	36	44	40	44	36	42	40	42	38	44	34	38	32	39	4700
144	Transom 36 (04)	JSB-K.K	0°	44	48	42	40	44	46	42	38	32	30	42	48	44	40	40	41	5000
145	Transom 37 (01)	JSB-K.K	0°	46	40	40	44	42	46	40	30	38	34	42	40	38	40	40	40	4900
146	Transom 37 (02)	JSB-K.K	0°	32	38	40	32	34	44	40	38	32	36	36	40	38	32	40	37	4200
147	Transom 37 (03)	JSB-K.K	0°	44	42	40	40	40	42	42	44	38	36	44	36	40	42	44	41	5000
148	Transom 37 (04)	JSB-K.K	0°	36	32	44	40	48	40	44	42	46	36	38	38	40	44	42	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
1	PIER1 (01) 1st	JSB-K.K	0°	52	52	52	56	52	52	46	48	50	44	42	50	50	48	56	50	7000
2	PIER1 (01) 2nd	JSB-K.K	0°	48	50	48	54	55	46	46	48	48	54	50	46	52	50	52	50	7000
3	PIER1 (02) 1st	JSB-K.K	0°	42	40	42	40	44	44	38	50	48	46	38	40	48	44	48	44	5700
4	PIER1 (02) 2nd	JSB-K.K	0°	50	44	42	44	44	36	42	42	46	34	42	40	36	44	42	41	5000
5	PIER1 (03) 1st	JSB-K.K	0°	38	40	48	40	44	44	42	40	36	44	48	46	46	44	42	43	5500
6	PIER1 (03) 2nd	JSB-K.K	0°	42	42	44	42	38	40	46	44	42	40	38	46	44	42	44	42	5200
7	PIER1 (04) 1st	JSB-K.K	0°	44	54	52	54	52	50	50	50	50	56	54	40	50	52	52	51	7100
4	PIER1 (04) 2nd	JSB-K.K	0°	48	50	48	44	50	48	50	48	50	44	46	44	46	50	40	47	6300
9	PIER1 (05) 1st	JSB-K.K	0°	52	42	50	44	54	40	42	40	42	32	38	30	36	46	54	42	5200
10	PIER1 (05) 2nd	JSB-K.K	0°	38	36	38	44	40	44	36	42	38	36	40	40	44	42	54	41	5000
11	PIER1 (06) 1st	JSB-K.K	0°	36	42	48	40	48	44	44	38	42	48	46	44	40	58	46	45	6000
12	PIER1 (06) 2nd	JSB-K.K	0°	34	32	38	38	40	54	40	42	36	40	46	42	42	40	38	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
13	PIER2 (01) 1st	JSB-K.K	0°	40	44	40	38	46	48	40	40	44	44	50	46	44	42	42	43	5500
14	PIER2 (01) 2nd	JSB-K.K	0°	50	46	40	50	50	48	44	48	40	52	42	38	40	44	40	44	5700
15	PIER2 (02) 1st	JSB-K.K	0°	50	40	48	52	52	40	44	48	54	50	45	42	52	46	38	47	6300
16	PIER2 (02) 2nd	JSB-K.K	0°	42	42	44	36	42	38	44	46	42	44	46	42	52	38	45	43	5500
17	PIER2 (03) 1st	JSB-K.K	0°	40	38	30	40	38	40	36	42	40	44	40	40	38	38	38	39	4700
18	PIER2 (03) 2nd	JSB-K.K	0°	38	36	32	44	40	42	48	44	42	40	44	40	48	38	38	41	5000
19	PIER2 (04) 1st	JSB-K.K	0°	36	36	52	42	46	40	40	44	42	40	44	42	52	38	40	43	5500
20	PIER2 (04) 2nd	JSB-K.K	0°	30	36	30	42	32	38	30	46	40	40	40	44	48	30	46	39	4700
21	PIER2 (05) 1st	JSB-K.K	0°	40	44	50	42	40	42	46	48	44	50	44	40	50	46	38	45	6000
22	PIER2 (05) 2nd	JSB-K.K	0°	38	40	38	46	52	42	50	46	50	48	48	42	50	40	46	46	6100
23	PIER2 (06) 1st	JSB-K.K	0°	42	38	50	48	48	50	38	32	42	44	38	42	36	40	42	42	5200
24	PIER2 (06) 2nd	JSB-K.K	0°	42	50	48	48	38	40	44	42	40	50	52	50	42	48	38	45	6000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
25	PIER3 (01) 1st	JSB-K.K	0°	38	40	42	42	40	40	42	40	42	40	42	42	46	38	46	41	5000
26	PIER3 (01) 2nd	JSB-K.K	0°	36	46	50	54	42	32	40	38	46	34	32	30	36	44	30	40	4900
27	PIER3 (02) 1st	JSB-K.K	0°	48	44	42	44	40	40	48	50	52	54	45	52	46	46	40	46	6100
28	PIER3 (02) 2nd	JSB-K.K	0°	42	44	50	46	50	50	54	44	52	48	42	50	50	46	50	48	6500
29	PIER3 (03) 1st	JSB-K.K	0°	38	40	44	42	38	44	50	46	46	50	40	44	52	50	48	45	6000
30	PIER3 (03) 2nd	JSB-K.K	0°	42	38	44	50	38	48	54	46	50	50	44	52	48	46	42	46	6100
31	PIER3 (04) 1st	JSB-K.K	0°	42	38	32	44	40	34	48	46	38	40	44	34	46	44	50	41	5000
32	PIER3 (04) 2nd	JSB-K.K	0°	36	40	44	38	58	50	50	46	48	52	44	44	54	40	50	47	6300
33	PIER3 (05) 1st	JSB-K.K	0°	42	42	38	36	36	42	50	42	40	44	40	38	36	50	46	41	5000
34	PIER3 (05) 2nd	JSB-K.K	0°	42	42	42	38	46	42	48	44	50	42	44	40	44	34	38	42	5200
35	PIER3 (06) 1st	JSB-K.K	0°	36	32	38	42	40	46	50	50	44	40	46	56	40	42	38	43	5500
36	PIER3 (06) 2nd	JSB-K.K	0°	40	36	44	54	46	46	40	46	40	42	38	44	42	36	46	43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
37	PIER4 (01) 1st	JSB-K.K	0°	40	40	48	44	40	38	34	34	42	42	40	44	40	30	42	40	4900
38	PIER4 (01) 2nd	JSB-K.K	0°	36	40	36	46	38	48	50	42	48	42	44	40	42	44	40	43	5500
39	PIER4 (02) 1st	JSB-K.K	0°	38	46	38	44	46	46	52	46	52	46	38	42	48	40	38	44	5700
40	PIER4 (02) 2nd	JSB-K.K	0°	40	40	36	48	48	42	48	40	40	42	48	40	42	46	44	43	5500
41	PIER4 (03) 1st	JSB-K.K	0°	42	46	40	40	46	44	46	42	40	44	46	44	32	38	42	42	5200
42	PIER4 (03) 2nd	JSB-K.K	0°	48	42	42	40	42	42	42	40	44	38	32	40	42	32	38	40	4900
43	PIER4 (04) 1st	JSB-K.K	0°	46	40	38	46	30	40	44	32	30	42	36	34	42	38	40	38	4500
44	PIER4 (04) 2nd	JSB-K.K	0°	42	42	48	36	34	44	40	42	42	40	38	42	40	34	48	41	5000
45	PIER4 (05) 1st	JSB-K.K	0°	34	36	42	38	42	44	42	40	52	54	42	44	44	42	36	43	5500
46	PIER4 (05) 2nd	JSB-K.K	0°	48	40	40	32	48	40	40	40	46	40	40	40	42	40	42	41	5000
47	PIER4 (06) 1st	JSB-K.K	0°	36	44	42	44	46	44	44	46	50	40	46	44	42	42	42	44	5700
48	PIER4 (06) 2nd	JSB-K.K	0°	40	46	40	46	44	48	42	38	46	42	40	44	42	38	40	43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
49	PIER5 (01) 1st	JSB-K.K	0°	48	52	46	50	44	48	54	50	48	46	40	36	48	46	38	46	6100
50	PIER5 (01) 2nd	JSB-K.K	0°	42	48	42	38	50	46	42	42	40	42	46	36	50	50	42	44	5700
51	PIER5 (02) 1st	JSB-K.K	0°	50	50	54	48	42	42	40	42	40	44	48	54	42	46	40	45	6000
52	PIER5 (02) 2nd	JSB-K.K	0°	44	44	40	40	40	52	44	40	42	46	44	40	42	40	36	42	5200
53	PIER5 (03) 1st	JSB-K.K	0°	40	36	38	40	40	38	34	48	40	44	38	42	40	32	42	39	4700
54	PIER5 (03) 2nd	JSB-K.K	0°	48	42	42	44	48	36	44	42	38	48	44	38	44	48	42	43	5500
55	PIER5 (04) 1st	JSB-K.K	0°	42	44	36	42	44	38	44	48	46	50	38	42	36	44	42	42	5200
56	PIER5 (04) 2nd	JSB-K.K	0°	38	40	38	46	40	40	48	42	30	54	32	44	44	42	38	41	5000
57	PIER5 (05) 1st	JSB-K.K	0°	42	50	50	40	42	42	46	38	42	48	42	36	42	46	32	43	5500
58	PIER5 (05) 2nd	JSB-K.K	0°	48	46	40	40	42	38	30	52	38	50	42	46	46	40	38	42	5200
59	PIER5 (06) 1st	JSB-K.K	0°	38	44	40	40	46	54	40	44	40	46	42	38	26	42	46	42	5200
60	PIER5 (06) 2nd	JSB-K.K	0°	50	44	44	52	40	44	42	38	40	38	30	52	40	40	46	42	5200

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
61	PIER6 (01) 1st	JSB-K.K	0°	42	38	44	40	38	42	36	32	30	40	38	42	38	40	30	38	4500
62	PIER6 (01) 2nd	JSB-K.K	0°	40	36	40	44	48	36	30	40	40	42	44	36	34	40	40	39	4700
63	PIER6 (02) 1st	JSB-K.K	0°	42	36	40	40	42	42	38	44	42	36	40	38	44	40	40	40	4900
64	PIER6 (02) 2nd	JSB-K.K	0°	42	42	40	44	40	40	36	36	44	48	42	42	40	38	40	41	5000
65	PIER6 (03) 1st	JSB-K.K	0°	46	40	40	40	42	42	46	44	48	38	50	46	40	44	48	43	5500
66	PIER6 (03) 2nd	JSB-K.K	0°	44	40	46	40	42	46	40	42	42	38	40	38	40	46	42	42	5200
67	PIER6 (04) 1st	JSB-K.K	0°	34	32	50	40	36	44	38	40	36	34	40	38	38	36	40	39	4700
68	PIER6 (04) 2nd	JSB-K.K	0°	38	42	42	42	40	42	36	40	44	38	40	34	40	38	40	40	4900
69	PIER6 (05) 1st	JSB-K.K	0°	38	46	46	40	42	44	50	52	42	38	42	40	38	46	42	43	5500
70	PIER6 (05) 2nd	JSB-K.K	0°	48	44	42	42	38	40	40	38	30	46	40	44	42	46	38	41	5000
71	PIER6 (06) 1st	JSB-K.K	0°	34	32	36	32	30	34	36	34	40	42	40	36	32	28	32	35	3800
72	PIER6 (06) 2nd	JSB-K.K	0°	32	48	46	42	42	32	40	40	32	38	36	32	36	36	40	39	4700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
73	PIER7 (01) 1st	JSB-K.K	0°	46	50	50	42	48	48	46	48	52	44	50	46	40	46	48	47	6300
74	PIER7 (01) 2nd	JSB-K.K	0°	40	44	44	46	46	48	44	40	44	40	44	40	42	44	46	44	5700
75	PIER7 (02) 1st	JSB-K.K	0°	50	46	42	50	40	46	48	54	40	44	44	44	46	44	42	45	6000
76	PIER7 (02) 2nd	JSB-K.K	0°	50	42	46	42	42	44	40	46	50	40	38	48	44	50	46	44	5700
77	PIER7 (03) 1st	JSB-K.K	0°	44	44	36	42	40	40	42	50	46	40	40	46	50	48	48	44	5700
78	PIER7 (03) 2nd	JSB-K.K	0°	42	42	42	48	48	40	44	38	42	38	44	46	42	44	42	43	5200
79	PIER7 (04) 1st	JSB-K.K	0°	42	44	40	40	44	38	40	40	38	40	42	42	42	44	48	42	5200
80	PIER7 (04) 2nd	JSB-K.K	0°	30	44	36	42	48	50	42	36	46	38	40	42	46	42	46	43	5500
81	PIER7 (05) 1st	JSB-K.K	0°	42	42	38	38	40	40	42	42	32	38	40	40	46	34	40	39	4700
82	PIER7 (05) 2nd	JSB-K.K	0°	40	34	32	36	36	32	34	40	36	34	34	36	30	36	38	35	3800
83	PIER7 (06) 1st	JSB-K.K	0°	42	42	38	40	32	42	38	46	34	44	48	40	46	46	40	41	5000
84	PIER7 (06) 2nd	JSB-K.K	0°	46	44	46	54	42	40	38	42	44	46	42	40	38	42	40	43	5200

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
85	PIER8 (01) 1st	JSB-K.K	0°	46	44	48	42	46	40	38	40	42	40	44	50	42	44	38	43	5500
86	PIER8 (01) 2nd	JSB-K.K	0°	42	46	44	42	46	44	46	40	42	42	44	40	40	42	46	43	5500
87	PIER8 (02) 1st	JSB-K.K	0°	46	40	38	44	38	42	38	46	50	42	40	44	42	44	42	42	5200
88	PIER8 (02) 2nd	JSB-K.K	0°	38	44	38	40	36	40	48	44	48	38	44	52	40	36	34	42	5200
89	PIER8 (03) 1st	JSB-K.K	0°	42	36	40	36	42	44	42	48	30	44	38	42	40	38	44	40	4900
90	PIER8 (03) 2nd	JSB-K.K	0°	32	42	44	36	42	46	38	44	40	48	40	32	42	40	30	40	4900
91	PIER8 (04) 1st	JSB-K.K	0°	38	40	42	38	36	40	42	38	42	46	48	48	44	48	42	42	5200
92	PIER8 (04) 2nd	JSB-K.K	0°	36	40	44	36	48	42	40	42	38	50	40	42	42	40	44	42	5200
93	PIER8 (05) 1st	JSB-K.K	0°	38	32	42	34	42	42	46	40	44	46	32	40	44	54	42	41	5000
94	PIER8 (05) 2nd	JSB-K.K	0°	46	40	42	44	36	46	44	54	50	40	44	42	50	46	44	44	5700
95	PIER8 (06) 1st	JSB-K.K	0°	44	40	42	42	44	46	40	40	44	36	44	38	30	40	38	40	4900
96	PIER8 (06) 2nd	JSB-K.K	0°	46	40	40	42	46	50	56	48	40	50	42	50	42	42	44	45	6000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
97	PIER10 (01) 1st	JSB-K.K	0°	42	46	42	50	38	52	50	48	48	46	42	38	40	42	39	44	5700
98	PIER10 (01) 2nd	JSB-K.K	0°	52	44	44	44	44	42	48	44	46	44	45	43	40	44	40	44	5700
99	PIER10 (02) 1st	JSB-K.K	0°	56	52	48	48	46	46	48	52	54	46	44	46	52	48	44	48	6500
100	PIER10 (02) 2nd	JSB-K.K	0°	42	38	40	34	38	36	40	32	38	42	40	38	36	40	38	38	4500
101	PIER10 (03) 1st	JSB-K.K	0°	52	52	54	54	50	48	46	50	52	54	50	51	48	54	46	51	7100
102	PIER10 (03) 2nd	JSB-K.K	0°	30	48	44	42	42	38	44	44	38	44	36	32	40	44	46	42	5200
103	PIER10 (04) 1st	JSB-K.K	0°	48	44	48	46	50	52	48	54	50	48	42	46	52	48	44	48	6500
104	PIER10 (04) 2nd	JSB-K.K	0°	40	44	42	38	48	44	38	40	42	48	42	40	38	44	42	42	5200
105	PIER10 (05) 1st	JSB-K.K	0°	44	46	50	48	44	40	48	44	42	42	40	44	48	50	46	45	6000
106	PIER10 (05) 2nd	JSB-K.K	0°	40	44	44	40	42	44	40	46	38	38	36	40	42	40	42	41	5000
107	PIER10 (06) 1st	JSB-K.K	0°	46	48	48	46	50	48	46	44	46	48	44	48	50	46	44	47	6300
108	PIER10 (06) 2nd	JSB-K.K	0°	40	46	48	48	38	44	42	48	40	42	44	40	38	46		43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
109	PIER11 (01) 1st	JSB-K.K	0°	44	40	38	42	46	44	40	44	38	40	42	40	38	46	42	42	5200
110	PIER11 (01) 2nd	JSB-K.K	0°	48	42	40	44	38	40	42	40	40	40	42	38	40	44	42	41	5000
111	PIER11 (02) 1st	JSB-K.K	0°	42	44	44	40	42	34	38	40	38	40	42	34	38	44	44	40	4900
112	PIER11 (02) 2nd	JSB-K.K	0°	40	38	40	36	42	48	36	42	44	46	36	42	44	48	40	42	5200
113	PIER11 (03) 1st	JSB-K.K	0°	44	46	38	46	44	42	40	44	42	42	40	46	40	38	40	42	5200
114	PIER11 (03) 2nd	JSB-K.K	0°	44	44	40	42	46	48	50	52	46	46	46	40	40	42	42	45	6000
115	PIER11 (04) 1st	JSB-K.K	0°	42	44	42	44	46	42	38	44	46	38	34	42	46	44	40	42	5200
116	PIER11 (04) 2nd	JSB-K.K	0°	46	42	42	42	44	38	42	44	38	48	42	42	46	38	44	42	5200
117	PIER11 (05) 1st	JSB-K.K	0°	52	52	54	44	48	46	44	48	50	40	44	50	46	48	52	48	6500
118	PIER11 (05) 2nd	JSB-K.K	0°	52	54	54	46	50	46	48	50	52	44	46	50	54	48	46	49	6700
119	PIER11 (06) 1st	JSB-K.K	0°	46	54	48	38	50	52	48	44	52	50	38	50	48	44	48	47	6300
120	PIER11 (06) 2nd	JSB-K.K	0°	44	48	46	44	44	44	40	40	46	42	44	40	42	46	44	44	5700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
121	PIER12 (01) 1st	JSB-K.K	0°	46	44	44	48	46	42	48	40	46	48	42	44	46	40	42	44	5700
122	PIER12 (01) 2nd	JSB-K.K	0°	42	44	46	52	48	44	44	32	34	46	40	34	46	44	40	42	5200
123	PIER12 (02) 1st	JSB-K.K	0°	48	50	46	48	42	48	48	42	46	48	46	48	42	46	41	46	6100
124	PIER12 (02) 2nd	JSB-K.K	0°	52	48	44	48	50	48	58	54	40	48	52	56	50	50	44	49	6700
125	PIER12 (03) 1st	JSB-K.K	0°	40	42	42	44	46	40	48	46	48	38	44	46	40	42	46	44	5700
126	PIER12 (03) 2nd	JSB-K.K	0°	36	44	46	48	46	38	44	48	50	44	44	46	48	50	36	45	6000
127	PIER12 (04) 1st	JSB-K.K	0°	38	42	36	40	38	36	32	44	44	38	36	40	38	36	38	38	4500
128	PIER12 (04) 2nd	JSB-K.K	0°	34	42	40	38	42	46	48	40	44	48	40	38	46	44	40	43	5500
129	PIER12 (05) 1st	JSB-K.K	0°	42	40	42	44	44	38	44	46	40	48	42	44	46	40	44	43	5500
130	PIER12 (05) 2nd	JSB-K.K	0°	48	50	38	44	32	30	44	48	48	40	44	38	50	32	48	42	5200
131	PIER12 (06) 1st	JSB-K.K	0°	52	48	54	50	48	48	50	42	40	58	50	54	48	50	42	49	6700
132	PIER12 (06) 2nd	JSB-K.K	0°	48	50	44	44	54	48	46	48	44	50	44	46	48	44	46	47	6300

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
133	PIER13 (01) 1st	JSB-K.K	0°	37	52	44	44	42	42	46	42	48	50	42	44	39	40	50	44	5700
134	PIER13 (01) 2nd	JSB-K.K	0°	52	48	54	40	50	48	54	52	56	44	40	44	42	48	50	48	6500
135	PIER13 (02) 1st	JSB-K.K	0°	32	34	30	42	38	38	48	48	36	40	38	42	34	46	40	40	4900
136	PIER13 (02) 2nd	JSB-K.K	0°	48	50	48	50	44	48	40	46	40	54	44	46	46	40	40	45	6000
137	PIER13 (03) 1st	JSB-K.K	0°	48	46	42	44	52	54	52	48	54	50	42	42	48	48	40	47	6300
138	PIER13 (03) 2nd	JSB-K.K	0°	44	42	44	34	46	40	40	42	44	42	44	42	40	44	42	42	5200
139	PIER13 (04) 1st	JSB-K.K	0°	52	48	52	52	46	48	44	42	52	44	46	44	50	52	48	48	6500
140	PIER13 (04) 2nd	JSB-K.K	0°	40	44	42	38	40	42	40	44	40	44	42	38	42	40	42	41	5000
141	PIER13 (05) 1st	JSB-K.K	0°	48	50	44	48	42	44	44	46	52	50	50	48	44	44	42	46	6100
142	PIER13 (05) 2nd	JSB-K.K	0°	44	44	36	46	44	48	40	40	50	46	44	40	38	42	42	43	5500
143	PIER13 (06) 1st	JSB-K.K	0°	46	50	54	52	50	48	54	52	48	56	50	52	54	48	46	51	7100
144	PIER13 (06) 2nd	JSB-K.K	0°	38	42	40	40	36	38	44	44	30	36	40	36	38	40	42	39	4700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
145	PIER14 (01) 1st	JSB-K.K	0°	50	50	56	48	50	54	48	52	54	50	50	48	56	50	52	51	7100
146	PIER14 (01) 2nd	JSB-K.K	0°	48	52	58	54	48	52	56	58	48	46	48	52	56	48	46	52	7200
147	PIER14 (02) 1st	JSB-K.K	0°	46	52	56	44	52	50	48	50	56	54	50	54	52	46	48	51	7100
148	PIER14 (02) 2nd	JSB-K.K	0°	44	50	48	50	52	46	54	42	46	50	42	46	48	50	46	48	6500
149	PIER14 (03) 1st	JSB-K.K	0°	54	52	48	50	56	54	52	50	56	58	50	52	54	48	46	52	7200
150	PIER14 (03) 2nd	JSB-K.K	0°	48	52	48	56	58	52	56	58	44	52	52	50	52	48	44	52	7200
151	PIER14 (04) 1st	JSB-K.K	0°	50	40	44	48	50	52	54	50	54	50	44	40	46	48	50	48	6500
152	PIER14 (04) 2nd	JSB-K.K	0°	52	50	54	42	56	52	54	48	44	56	42	46	50	48	44	49	6700
153	PIER14 (05) 1st	JSB-K.K	0°	54	56	50	56	58	52	48	56	50	48	50	52	48	46	50	51	7100
154	PIER14 (05) 2nd	JSB-K.K	0°	52	48	52	50	44	46	44	56	58	42	52	46	44	42	50	48	6500
155	PIER14 (06) 1st	JSB-K.K	0°	56	50	48	52	54	56	50	48	54	48	52	54	56	48	46	51	7100
156	PIER14 (06) 2nd	JSB-K.K	0°	54	46	52	52	54	48	50	50	46	44	46	48	46	50	46	48	6500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
157	PIER15 (01) 1st	JSB-K.K	0°	48	48	42	42	46	44	48	46	48	54	42	46	48	52	50	47	6300
158	PIER15 (01) 2nd	JSB-K.K	0°	52	42	40	38	46	44	40	40	48	42	38	40	44	42	40	42	5200
159	PIER15 (02) 1st	JSB-K.K	0°	38	36	46	32	44	48	44	42	48	44	38	40	44	42	44	42	5200
160	PIER15 (02) 2nd	JSB-K.K	0°	36	32	44	40	48	42	48	46	44	48	44	40	48	46	40	44	5700
161	PIER15 (03) 1st	JSB-K.K	0°	36	38	34	38	32	30	38	36	42	44	30	38	36	42	38	37	4200
162	PIER15 (03) 2nd	JSB-K.K	0°	32	38	46	44	52	48	52	56	46	50	38	42	46	38	44	46	6100
163	PIER15 (04) 1st	JSB-K.K	0°	52	48	54	50	38	46	34	38	48	44	40	44	40	52	50	45	6000
164	PIER15 (04) 2nd	JSB-K.K	0°	50	40	32	32	36	30	34	36	44	38	36	38	40	44	41	37	4200
165	PIER15 (05) 1st	JSB-K.K	0°	42	46	40	40	44	40	38	40	44	50	40	44	42	42	38	42	5200
166	PIER15 (05) 2nd	JSB-K.K	0°	44	45	44	52	50	40	46	54	58	48	46	40	52	54	50	49	6700
167	PIER15 (06) 1st	JSB-K.K	0°	42	42	50	52	38	48	50	42	46	42	38	40	42	40	46	44	5700
168	PIER15 (06) 2nd	JSB-K.K	0°	54	44	38	42	54	50	48	44	56	38	42	48	44	42	40	45	6000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
169	PIER16 (01) 1st	JSB-K.K	0°	46	52	44	52	32	46	48	50	58	52	52	50	48	46	50	48	6500
170	PIER16 (01) 2nd	JSB-K.K	0°	52	54	48	50	48	44	54	58	48	46	50	48	48	46	54	50	7000
171	PIER16 (02) 1st	JSB-K.K	0°	40	38	42	46	44	38	42	36	46	44	42	44	46	38	40	42	5200
172	PIER16 (02) 2nd	JSB-K.K	0°	46	44	44	42	40	50	48	46	48	48	40	50	48	46	48	46	6100
173	PIER16 (03) 1st	JSB-K.K	0°	46	44	48	40	44	42	44	42	42	46	40	44	42	46	42	43	5500
174	PIER16 (03) 2nd	JSB-K.K	0°	46	48	52	40	48	46	48	44	46	42	40	48	44	46	42	45	6000
175	PIER16 (04) 1st	JSB-K.K	0°	50	42	48	46	52	54	44	46	44	36	42	50	44	46	38	45	6000
176	PIER16 (04) 2nd	JSB-K.K	0°	44	50	48	52	54	50	38	36	44	48	50	48	48	46	52	47	6300
177	PIER16 (05) 1st	JSB-K.K	0°	50	48	38	44	52	42	50	48	38	42	38	38	40	42	44	43	5500
178	PIER16 (05) 2nd	JSB-K.K	0°	48	52	42	46	48	44	48	42	44	50	46	48	52	46	46	47	6300
179	PIER16 (06) 1st	JSB-K.K	0°	48	56	42	38	44	50	48	46	52	38	38	44	42	50	56	46	6100
180	PIER16 (06) 2nd	JSB-K.K	0°	50	42	44	38	42	52	58	44	48	52	44	42	52	50	48	47	6300

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
181	PIER17 (01) 1st	JSB-K.K	0°	50	42	38	42	44	48	50	52	42	44	52	48	44	58	52	47	6300
182	PIER17 (01) 2nd	JSB-K.K	0°	50	56	44	42	38	48	56	42	38	44	50	46	48	38	38	45	6000
183	PIER18 (01) 1st	JSB-K.K	0°	40	42	36	38	38	44	42	40	42	40	42	38	36	42	40	40	4900
184	PIER18 (01) 2nd	JSB-K.K	0°	52	43	48	42	43	42	44	42	42	40	42	43	40	44	38	42	5200
185	PIER18 (02) 1st	JSB-K.K	0°	40	48	38	48	40	38	40	42	40	38	44	40	42	38	40	41	5000
186	PIER18 (02) 2nd	JSB-K.K	0°	40	38	38	42	38	42	40	38	44	38	40	40	38	44	38	40	4900
187	PIER18 (03) 1st	JSB-K.K	0°	48	48	50	44	50	48	52	41	52	48	50	52	50	48	44	48	6500
188	PIER19 (01) 1st	JSB-K.K	0°	28	30	28	26	30	30	32	26	32	32	30	28	32	32	28	30	3000
189	PIER19 (01) 2nd	JSB-K.K	0°	26	26	20	20	18	22	18	20	24	24	24	20	28	24	26	22	2300
190	PIER19 (02) 1st	JSB-K.K	0°	34	34	30	32	36	32	34	30	32	30	34	30	32	34	34	32	3300
191	PIER19 (02) 2nd	JSB-K.K	0°	40	36	38	36	42	40	36	32	36	38	36	38	40	38	42	38	4500
192	PIER20 (01) 1st	JSB-K.K	0°	50	48	44	42	52	40	48	46	48	50	44	40	48	40	46	45	6000
193	PIER20 (02) 2nd	JSB-K.K	0°	40	40	46	42	44	48	44	48	38	42	40	46	40	48	46	44	5700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
194	PIER21 (01) 1st	JSB-K.K	0°	40	38	32	40	42	48	30	34	42	44	42	38	36	42	44	39	4700
195	PIER21 (01) 2nd	JSB-K.K	0°	44	40	40	42	46	48	50	52	48	50	46	48	50	52	42	47	6300
196	PIER22 (01) 1st	JSB-K.K	0°	40	38	44	40	46	42	38	48	46	38	40	38	42	40	40	41	5000
197	PIER22 (01) 2nd	JSB-K.K	0°	32	30	36	38	44	36	32	38	40	40	38	34	38	36	40	37	4200
198	PIER22 (02) 1st	JSB-K.K	0°	44	44	34	42	42	38	40	40	32	40	40	36	42	40	38	39	4700
199	PIER23 (01) 2nd	JSB-K.K	0°	44	40	48	34	40	44	42	38	46	44	40	42	44	38	40	41	5000
200	PIER23 (02) 1st	JSB-K.K	0°	40	46	44	38	36	48	46	34	48	44	44	46	48	34	46	43	5500
201	PIER24 (03) 1st	JSB-K.K	0°	40	38	48	46	36	44	40	38	38	48	46	38	36	40	48	42	5200
202	PIER24 (03) 2nd	JSB-K.K	0°	38	34	40	36	38	32	34	40	36	32	40	32	40	34	38	36	4000
203	PIER24 (04) 1st	JSB-K.K	0°	38	40	42	42	34	32	34	40	40	42	34	40	42	38	40	39	4700
204	PIER24 (04) 2nd	JSB-K.K	0°	42	36	44	44	40	44	32	44	48	40	44	32	48	40	44	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

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Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
205	PIER25 (01) 1st	JSB-K.K	0°	46	42	42	44	38	34	46	42	50	50	44	46	38	50	42	44	5700
206	PIER25 (01) 2nd	JSB-K.K	0°	38	32	40	30	32	38	32	34	48	36	32	30	38	36	42	36	4000
207	PIER25 (02) 1st	JSB-K.K	0°	40	40	36	32	40	38	42	40	34	34	40	36	34	38	40	37	4200
208	PIER25 (02) 2nd	JSB-K.K	0°	48	44	50	44	44	40	42	40	40	44	42	40	44	42	50	43	5500
209	PIER25 (03) 1st	JSB-K.K	0°	44	44	42	46	50	48	38	40	44	48	46	44	40	44	48	44	5700
210	PIER25 (03) 2nd	JSB-K.K	0°	34	44	32	44	46	34	40	32	32	36	34	36	34	32	40	37	4200
211	PIER25 (04) 1st	JSB-K.K	0°	26	28	24	26	28	30	38	24	26	26	28	28	30	26	28	28	2900
212	PIER25 (04) 2nd	JSB-K.K	0°	42	40	40	34	38	34	38	46	42	34	40	38	34	38	40	38	4500
213	PIER25 (05) 1st	JSB-K.K	0°	36	40	44	32	36	40	34	34	32	38	44	36	40	42	38	38	4500
214	PIER25 (05) 2nd	JSB-K.K	0°	38	38	40	34	28	38	30	44	32	42	30	34	38	42	40	36	4000
215	PIER25 (06) 1st	JSB-K.K	0°	24	22	20	24	24	24	26	24	36	22	30	24	26	30	36	26	2400
216	PIER25 (06) 2nd	JSB-K.K	0°	36	30	46	40	48	48	44	44	42	48	40	44	42	44	48	43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
217	PIER26 (01) 1st	JSB-K.K	0°	44	52	40	54	52	54	32	52	54	48	50	46	52	46	40	48	6500
218	PIER26 (01) 2nd	JSB-K.K	0°	40	44	40	38	40	32	40	46	34	42	38	34	46	40	40	40	4900
219	PIER26 (02) 1st	JSB-K.K	0°	50	46	44	42	44	54	44	42	52	54	38	44	36	42	44	45	6000
220	PIER26 (02) 2nd	JSB-K.K	0°	44	48	44	50	52	48	44	48	52	40	46	42	44	48	40	46	6100
221	PIER26 (03) 1st	JSB-K.K	0°	36	42	42	40	44	54	42	42	42	48	42	44	40	50	38	44	5700
222	PIER26 (03) 2nd	JSB-K.K	0°	38	40	40	44	46	52	48	42	50	48	44	42	46	44	42	45	6000
223	PIER26 (04) 1st	JSB-K.K	0°	38	46	40	44	42	42	44	44	38	40	42	34	42	44	48	42	5200
224	PIER26 (04) 2nd	JSB-K.K	0°	46	38	34	46	40	38	42	34	38	40	38	40	36	40	42	39	4700
225	PIER26 (05) 1st	JSB-K.K	0°	32	40	42	38	44	40	40	38	40	34	36	34	40	42	40	39	4700
226	PIER26 (05) 2nd	JSB-K.K	0°	40	38	38	42	42	38	40	36	38	40	44	34	38	38	42	39	4700
227	PIER26 (06) 1st	JSB-K.K	0°	36	42	40	44	40	42	40	46	44	36	38	40	44	42	38	41	5000
228	PIER26 (06) 2nd	JSB-K.K	0°	44	48	44	42	40	46	42	40	40	40	42	48	46	42	38	43	5500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
229	PIER27 (01) 1st	JSB-K.K	0°	42	38	42	38	36	44	52	46	48	44	42	40	42	48	42	43	5500
230	PIER27 (01) 2nd	JSB-K.K	0°	34	40	38	28	40	44	38	36	34	44	44	40	40	36	42	39	4700
231	PIER27 (02) 1st	JSB-K.K	0°	40	40	42	40	44	46	44	42	34	40	48	44	34	38	46	42	5200
232	PIER27 (02) 2nd	JSB-K.K	0°	38	40	36	34	38	36	30	32	36	42	32	36	30	32	34	35	3800
233	PIER27 (03) 1st	JSB-K.K	0°	42	38	40	42	38	40	46	40	44	42	44	50	42	42	44	42	5200
234	PIER27 (03) 2nd	JSB-K.K	0°	38	30	38	42	36	30	42	32	40	34	38	38	34	40	30	36	4000
235	PIER27 (04) 1st	JSB-K.K	0°	42	40	46	40	50	52	44	44	48	46	44	54	46	42	36	45	6000
236	PIER27 (04) 2nd	JSB-K.K	0°	42	50	48	44	50	48	40	44	52	52	48	42	46	46	48	47	6300
237	PIER27 (05) 1st	JSB-K.K	0°	42	46	34	44	50	44	40	42	48	52	40	44	42	42	46	44	5700
238	PIER27 (05) 2nd	JSB-K.K	0°	42	36	34	34	32	38	42	30	32	30	46	30	34	38	32	35	3800
239	PIER27 (06) 1st	JSB-K.K	0°	48	52	40	38	40	44	50	46	42	46	44	48	52	52	50	46	6100
240	PIER27 (06) 2nd	JSB-K.K	0°	46	40	46	50	36	44	44	40	42	36	42	40	40	44	32	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
241	PIER28 (01) 1st	JSB-K.K	0°	42	38	40	42	38	42	44	40	40	44	42	48	46	46	44	42	5200
242	PIER28 (01) 2nd	JSB-K.K	0°	48	44	32	38	42	44	40	40	52	38	42	48	52	44	40	43	5500
243	PIER28 (02) 1st	JSB-K.K	0°	42	46	32	40	34	30	36	40	34	42	38	40	38	42	36	38	4500
244	PIER28 (02) 2nd	JSB-K.K	0°	40	42	38	36	42	48	36	32	38	36	40	36	42	46	30	39	4700
245	PIER28 (03) 1st	JSB-K.K	0°	34	44	38	40	42	44	38	38	42	42	46	36	48	36	42	41	5000
246	PIER28 (03) 2nd	JSB-K.K	0°	38	44	30	38	42	36	30	36	44	40	42	48	46	40	38	40	4900
247	PIER28 (04) 1st	JSB-K.K	0°	42	44	44	42	40	48	44	38	50	46	40	42	42	38	40	43	5500
248	PIER28 (04) 2nd	JSB-K.K	0°	40	42	38	30	32	40	42	46	44	40	38	40	38	40	46	40	4900
249	PIER28 (05) 1st	JSB-K.K	0°	40	36	40	48	42	38	40	40	38	34	42	42	36	36	38	39	4700
250	PIER28 (05) 2nd	JSB-K.K	0°	42	42	40	44	42	42	42	40	40	44	38	48	40	38	40	41	5000
251	PIER28 (06) 1st	JSB-K.K	0°	44	38	40	44	42	32	38	44	32	36	48	40	42	40	44	40	4900
252	PIER28 (06) 2nd	JSB-K.K	0°	40	44	44	36	36	40	38	34	34	40	38	32	42	42	40	39	4700

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
253	PIER30 (01) 1st	JSB-K.K	0°	46	50	50	46	50	40	40	50	52	48	54	42	40	50	46	47	6300
254	PIER30 (01) 2nd	JSB-K.K	0°	50	42	38	38	36	44	40	42	42	50	46	44	42	38	36	41	5000
255	PIER30 (02) 1st	JSB-K.K	0°	44	48	54	46	40	44	46	50	32	40	46	48	46	40	52	45	6000
256	PIER30 (02) 2nd	JSB-K.K	0°	40	46	44	48	46	50	42	50	54	48	48	44	42	50	42	47	6300
257	PIER30 (03) 1st	JSB-K.K	0°	54	48	46	46	48	50	44	46	48	44	42	44	44	42	42	45	6000
258	PIER30 (03) 2nd	JSB-K.K	0°	40	40	40	42	40	42	44	46	42	40	38	40	38	40	36	41	5000
259	PIER30 (04) 1st	JSB-K.K	0°	38	36	46	40	38	40	38	38	42	40	40	44	44	46	44	41	5000
260	PIER30 (04) 2nd	JSB-K.K	0°	48	50	40	44	50	46	56	42	48	52	46	40	42	50	48	47	6300
261	PIER30 (05) 1st	JSB-K.K	0°	40	42	40	42	38	40	44	42	46	42	38	38	48	48	44	42	5200
262	PIER30 (05) 2nd	JSB-K.K	0°	44	48	44	48	38	36	36	34	44	42	36	44	40	48	52	42	5200
263	PIER30 (06) 1st	JSB-K.K	0°	44	48	42	46	52	52	50	40	42	46	54	48	44	48	38	46	6100
264	PIER30 (06) 2nd	JSB-K.K	0°	46	38	44	52	36	36	50	46	42	54	48	50	44	36	48	45	6000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
265	PIER31 (01) 1st	JSB-K.K	0°	46	42	42	40	46	40	44	40	44	44	44	46	42	42	42	43	5500
266	PIER31 (01) 2nd	JSB-K.K	0°	44	44	40	44	42	40	40	42	42	42	40	46	40	42	46	42	5200
267	PIER31 (02) 1st	JSB-K.K	0°	40	40	42	40	44	44	36	48	42	44	44	44	42	42	36	42	5200
268	PIER31 (02) 2nd	JSB-K.K	0°	42	42	42	46	44	40	44	40	38	40	40	46	42	42	40	42	5200
269	PIER31 (03) 1st	JSB-K.K	0°	38	38	40	40	36	36	42	38	42	42	44	42	30	42	36	39	4700
270	PIER31 (03) 2nd	JSB-K.K	0°	42	40	42	44	40	38	38	40	40	40	46	44	44	36	44	41	5000
271	PIER31 (04) 1st	JSB-K.K	0°	38	40	40	36	36	38	40	40	42	38	40	42	42	42	38	40	4900
272	PIER31 (04) 2nd	JSB-K.K	0°	46	42	42	42	34	36	40	42	42	36	44	42	40	40	40	40	4900
273	PIER31 (05) 1st	JSB-K.K	0°	38	40	36	38	42	42	40	40	38	38	36	40	38	44	42	40	4900
274	PIER31 (05) 2nd	JSB-K.K	0°	40	42	38	40	38	46	40	40	40	44	40	40	42	42	40	41	5000
275	PIER31 (06) 1st	JSB-K.K	0°	38	42	40	42	42	44	40	42	42	40	38	38	42	42	40	41	5000
276	PIER31 (06) 2nd	JSB-K.K	0°	44	44	30	38	40	40	38	46	38	44	40	40	46	36	40	40	4900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
277	PIER32 (01) 1st	JSB-K.K	0°	40	46	40	42	42	40	36	38	44	44	50	48	46	40	40	42	5200
278	PIER32 (01) 2nd	JSB-K.K	0°	42	40	42	42	34	38	40	44	44	40	44	40	40	40	46	41	5000
279	PIER32 (02) 1st	JSB-K.K	0°	42	48	44	42	38	46	46	44	46	42	40	42	40	44	40	43	5500
280	PIER32 (02) 2nd	JSB-K.K	0°	44	44	48	42	38	42	46	40	44	46	44	40	42	46	36	43	5500
281	PIER32 (03) 1st	JSB-K.K	0°	38	46	38	42	42	46	42	44	38	50	40	40	44	46	44	43	5500
282	PIER32 (03) 2nd	JSB-K.K	0°	44	46	40	44	36	36	40	36	40	46	34	40	40	46	44	41	5000
283	PIER32 (04) 1st	JSB-K.K	0°	42	46	42	46	46	38	40	38	40	40	50	40	40	40	41	42	5200
284	PIER32 (04) 2nd	JSB-K.K	0°	46	40	38	42	42	40	38	42	48	40	36	40	34	40	38	40	4900
285	PIER32 (05) 1st	JSB-K.K	0°	42	44	38	38	40	46	44	38	42	42	30	38	46	40	40	40	4900
286	PIER32 (05) 2nd	JSB-K.K	0°	36	38	36	46	46	38	38	44	38	42	50	40	38	46	44	42	5200
287	PIER32 (06) 1st	JSB-K.K	0°	46	40	40	40	40	46	40	40	36	44	36	40	44	44	38	41	5000
288	PIER32 (06) 2nd	JSB-K.K	0°	40	40	40	38	46	38	42	38	44	44	40	40	38	48	44	41	5000

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
289	PIER33 (01) 1st	JSB-K.K	0°	34	36	42	38	38	34	36	40	32	34	36	36	34	36	30	36	4000
290	PIER33 (01) 2nd	JSB-K.K	0°	32	32	32	36	30	36	32	34	40	40	38	38	34	44	38	36	4000
291	PIER33 (02) 1st	JSB-K.K	0°	44	42	38	42	46	40	46	40	42	40	32	42	38	42	36	40	4900
292	PIER33 (02) 2nd	JSB-K.K	0°	34	38	36	34	38	30	40	40	38	36	36	40	36	42	38	37	4200
293	PIER33 (03) 1st	JSB-K.K	0°	38	38	36	38	36	38	36	38	44	40	46	38	42	38	38	39	4700
294	PIER33 (03) 2nd	JSB-K.K	0°	30	38	34	32	36	30	34	32	34	38	38	36	32	32	34	34	3700
295	PIER33 (04) 1st	JSB-K.K	0°	40	40	38	42	38	39	42	36	38	40	40	38	40	32	32	38	4500
296	PIER33 (04) 2nd	JSB-K.K	0°	32	38	40	38	32	36	38	42	34	34	36	28	40	32	34	36	4000
297	PIER33 (05) 1st	JSB-K.K	0°	42	40	40	32	30	39	42	36	35	32	32	38	36	32	35	36	4000
298	PIER33 (05) 2nd	JSB-K.K	0°	30	30	30	28	30	28	32	32	34	32	28	28	30	32	30	30	3000
299	PIER33 (06) 1st	JSB-K.K	0°	P	A	C	K	E	D	WITH	M	A	S	O	N	R	Y		#DIV/0!	
300	PIER33 (06) 2nd	JSB-K.K	0°																#DIV/0!	

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
301	PIER34 (01) 1st	JSB-K.K	0°	42	36	30	38	40	35	30	38	40	30	32	42	32	36	32	36	4000
302	PIER34 (01) 2nd	JSB-K.K	0°	40	40	36	38	38	38	32	34	34	40	40	32	38	40	42	37	4200
303	PIER34 (02) 1st	JSB-K.K	0°	30	38	40	30	30	28	32	30	40	48	30	32	30	35	32	34	3700
304	PIER34 (02) 2nd	JSB-K.K	0°	42	46	42	42	42	38	42	36	44	44	44	34	42	42	42	41	5000
305	PIER34 (03) 1st	JSB-K.K	0°	38	36	38	36	38	34	38	40	44	32	38	38	36	34	30	37	4200
306	PIER34 (03) 2nd	JSB-K.K	0°	32	32	38	38	36	32	40	40	38	36	44	42	44	40	44	39	4700
307	PIER34 (04) 1st	JSB-K.K	0°	42	40	40	44	48	46	34	40	40	38	38	34	42	40	34	40	4900
308	PIER34 (04) 2nd	JSB-K.K	0°	42	40	32	38	34	38	40	36	36	36	36	40	42	48	42	38	4500
309	PIER34 (05) 1st	JSB-K.K	0°	34	38	46	42	30	40	36	40	36	34	46	30	42	38	36	38	4500
310	PIER34 (05) 2nd	JSB-K.K	0°	40	40	40	32	34	32	34	36	40	44	36	40	46	34	38	38	4500
311	PIER34 (06) 1st	JSB-K.K	0°	38	40	38	36	34	38	34	34	30	36	40	32	38	40	30	36	4000
312	PIER34 (06) 2nd	JSB-K.K	0°	42	40	40	36	40	36	34	32	38	34	40	42	40	36	38	38	4500

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	9/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
313	PIER35 (01) 1st	JSB-K.K	0°	42	38	36	34	42	36	40	36	34	40	38	38	40	40	36	38	4500
314	PIER35 (01) 2nd	JSB-K.K	0°	42	40	38	40	44	40	44	42	46	46	42	40	46	40	40	42	5200
315	PIER35 (02) 1st	JSB-K.K	0°	44	36	36	42	44	42	32	44	42	48	44	42	46	44	40	42	5200
316	PIER35 (02) 2nd	JSB-K.K	0°	38	44	42	44	46	44	42	44	42	42	46	38	40	36	42	42	5200
317	PIER35 (03) 1st	JSB-K.K	0°	42	46	46	38	42	44	42	38	44	42	46	38	36	36	36	41	5000
318	PIER35 (03) 2nd	JSB-K.K	0°	32	46	38	44	38	40	48	42	46	40	30	34	38	30	44	40	4900
319	PIER35 (04) 1st	JSB-K.K	0°	44	42	42	42	40	42	38	44	40	40	40	46	42	44	44	42	5200
320	PIER35 (04) 2nd	JSB-K.K	0°	40	34	44	46	44	40	42	34	40	46	44	38	38	40	46	41	5000
321	PIER35 (05) 1st	JSB-K.K	0°	44	46	40	42	46	40	46	48	46	48	40	40	48	44	44	44	5700
322	PIER35 (05) 2nd	JSB-K.K	0°	36	32	44	34	46	38	30	38	30	36	32	30	28	34	30	34	3700
323	PIER35 (06) 1st	JSB-K.K	0°	30	32	38	36	40	34	42	36	44	40	32	42	46	40	36	38	4500
324	PIER35 (06) 2nd	JSB-K.K	0°	42	44	46	42	44	40	40	44	46	38	44	40	42	42	40	42	5200

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS														AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
325	PIER36 (01) 1st	JSB-K.K	0°																
326	PIER36 (01) 2nd	JSB-K.K	0°																
327	PIER36 (02) 1st	JSB-K.K	0°	38	36	34	36	38	40	38	38	34	34	36	30	32	34	30	35	3800
328	PIER36 (02) 2nd	JSB-K.K	0°	44	42	36	40	36	34	34	34	40	40	34	36	34	40	36	37	4200
329	PIER36 (03) 1st	JSB-K.K	0°	40	40	40	42	40	40	42	42	38	40	38	36	36	40	36	39	4700
330	PIER36 (03) 2nd	JSB-K.K	0°	42	40	36	40	36	38	38	36	36	38	36	34	34	34	38	37	4200
331	PIER36 (04) 1st	JSB-K.K	0°	28	36	32	42	28	30	32	38	36	30	28	42	38	30	28	34	3700
332	PIER36 (04) 2nd	JSB-K.K	0°	30	40	34	36	36	40	32	38	40	40	42	30	36	32	36	37	4200
333	PIER36 (05) 1st	JSB-K.K	0°	36	40	40	38	30	36	38	40	42	36	40	38	36	46	40	39	4700
334	PIER36 (05) 2nd	JSB-K.K	0°	36	36	38	32	40	34	36	36	40	34	36	40	34	38	34	36	4000
335	PIER36 (06) 1st	JSB-K.K	0°																	
336	PIER36 (06) 2nd	JSB-K.K	0°																	

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

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SCHMIDT HAMMER REPORT

Approved By: Managing Partner

Jam Sadiq Bridge

S#	MEMBER	LOCATION	Angle Orientation	READINGS															AVERAGE READINGS	SCHMIDT HAMMER RESULTS FINAL (fć) PSI
337	PIER37 (01) 1st	JSB-K.K	0°	32	32	36	34	34	32	38	32	36	32	30	30	30	38	40	34	3700
338	PIER37 (01) 2nd	JSB-K.K	0°	30	34	34	30	35	38	34	30	34	36	40	32	42	38	30	35	3800
339	PIER37 (02) 1st	JSB-K.K	0°	40	38	32	36	40	42	40	40	44	40	42	42	38	38	38	39	4700
340	PIER37 (02) 2nd	JSB-K.K	0°	44	40	40	42	38	42	40	28	34	30	32	48	44	46	44	39	4700
341	PIER37 (03) 1st	JSB-K.K	0°	46	44	34	42	40	36	36	34	36	40	38	40	40	44	36	39	4700
342	PIER37 (03) 2nd	JSB-K.K	0°	36	36	40	36	42	42	36	44	42	42	34	38	36	36	36	39	4700
343	PIER37 (04) 1st	JSB-K.K	0°	42	40	44	38	44	42	46	42	42	44	44	46	48	46	40	43	5500
344	PIER37 (04) 2nd	JSB-K.K	0°	36	38	40	34	34	38	40	38	30	28	30	32	32	36	38	35	3800
345	PIER37 (05) 1st	JSB-K.K	0°	40	38	36	32	38	38	40	36	36	34	36	32	40	34	32	36	4000
346	PIER37 (05) 2nd	JSB-K.K	0°	36	36	36	40	38	34	40	38	38	30	40	42	36	42	40	38	4500
347	PIER37 (06) 1st	JSB-K.K	0°	38	36	44	40	42	32	32	34	40	40	42	38	36	42	40	38	4500
348	PIER37 (06) 2nd	JSB-K.K	0°	42	44	40	40	38	36	32	38	42	42	48	46	40	40	32	40	4900

NOTE : Structure age can affecrt results of Schmidt Hammer from added hardness and carbonation

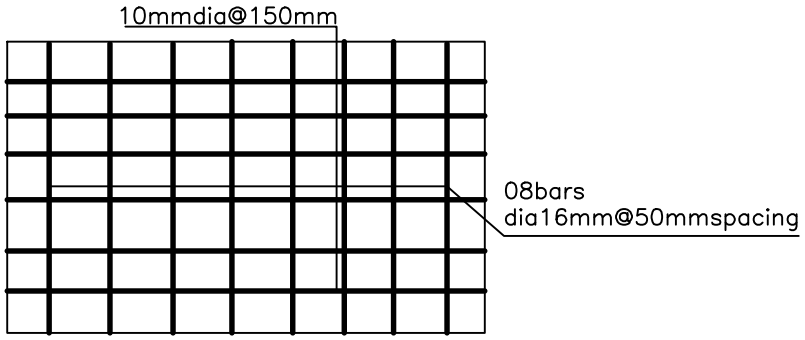
JOB #	J01-0003-10/21	Temperature:	34°	SH Serial #	N0711116

Particulars	Prepared By	Reviewed By
Name	Muhammad Irfan	Raheel Shaikh
Designation	Site Supervisor	Assistant Manager (Civil)
Signature		
Date	5/11/2021	9/11/2021

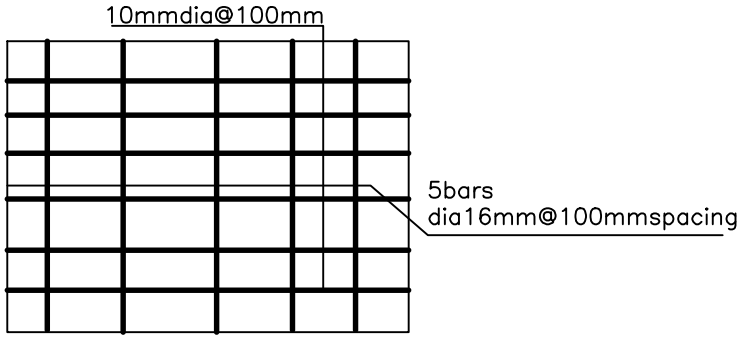
This document is issued by the F&M Engineering (PEC Licensed No Consult - 2098). Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any.

APPENDIX B – REBAR SCANNING (FERRO SCANNING)

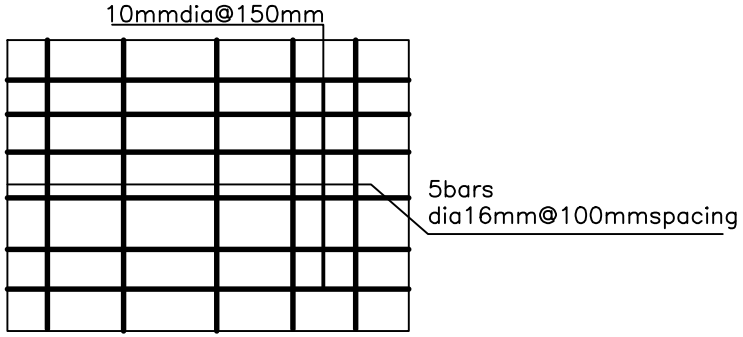
This document is issued by the F&M Engineering, Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that Information contained hereon reflects the Company's findings at the time of inspection only and within the limits of Client's instructions, if any



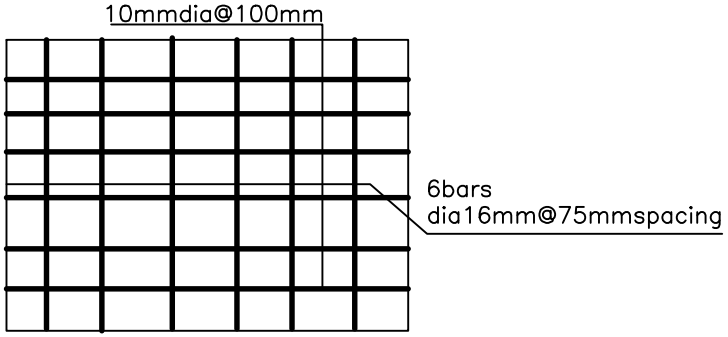
Deck slab grid 36 to 37
Concrete cover 35mm



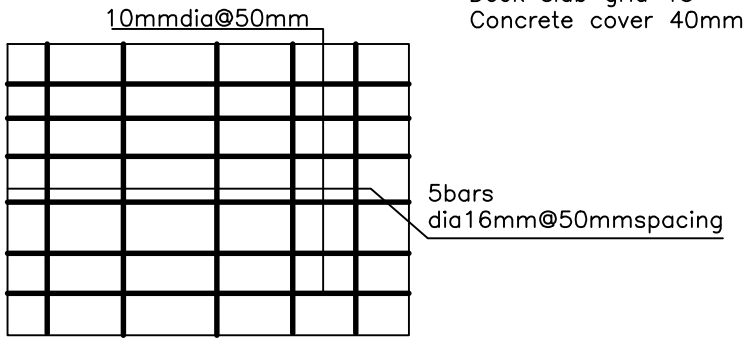
Deck slab grid 26
Concrete cover 35mm



Deck slab grid 5
Concrete cover 40mm



Deck slab grid 13
Concrete cover 40mm



Deck slab grid 11
Concrete cover 18mm

No.s	Identification	No of scans
1	Deck Grid 36	1 scan
2	Deck Grid 26	1 scan
3	Deck Grid 5	1 scan
4	Deck Grid 13	1 scan
5	Deck Grid 11	1 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: JO1-0003-10/21

DRAWING TITLE:
Scanning Section Deck Slab

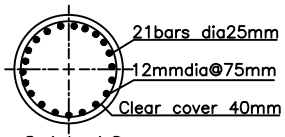
DRAWN BY : ENGR RAHEEL SHAIKH

APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

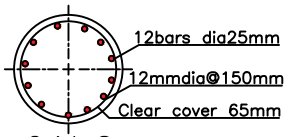
DATE : 11/NOV/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

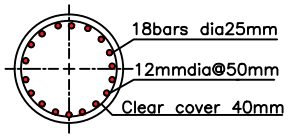
Drawing No:	Revision
S-01	0-0



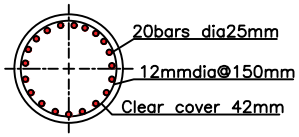
Grid 10
Pier 01



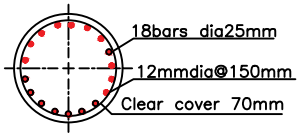
Grid 8
Pier 05



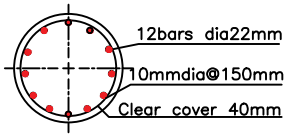
Grid 37
Pier 01



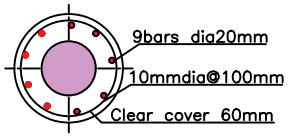
Grid 27
Pier 01



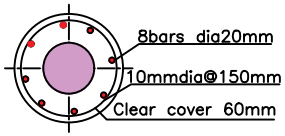
Grid 30
Pier 04



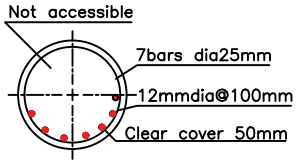
Grid 7
Pier 4



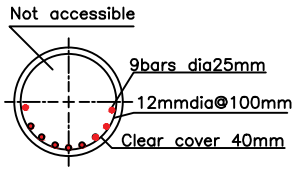
Grid 14
Pier 01 jacket



Grid 12
Pier 05 jacket



Grid 21
Pier 01



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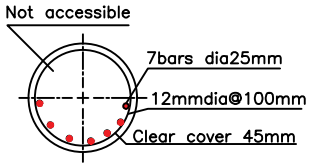
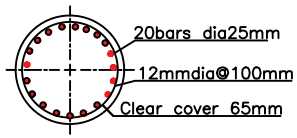
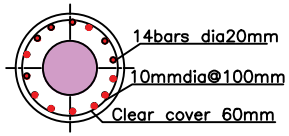
Pier 01



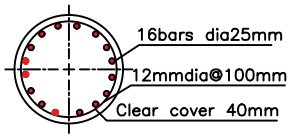
Grid 18
Pier 01



Grid 26
Pier 02



Grid 14
Pier 04 jacket



Grid 25
Pier 01

No.s	Identification	No of scans
1	Grid 10 Pier 01	6 scan
2	Grid 08 Pier 05	4 scan
3	Grid 37 Pier 01	5 scan
4	Grid 27 Pier 01	6 scan
5	Grid 30 Pier 04	5 scan
6	Grid 07 Pier 04	4 scan
7	Grid 14 J.Pier 01	7 scan
8	Grid 12 J.Pier 05	7 scan
9	Grid 21 Pier 01	3 scan
10	Grid 20 Pier 01	3 scan
11	Grid 18 Pier 01	3 scan
12	Grid 26 Pier 01	6 scan
13	Grid 25 Pier 01	6 scan
	Total	65

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

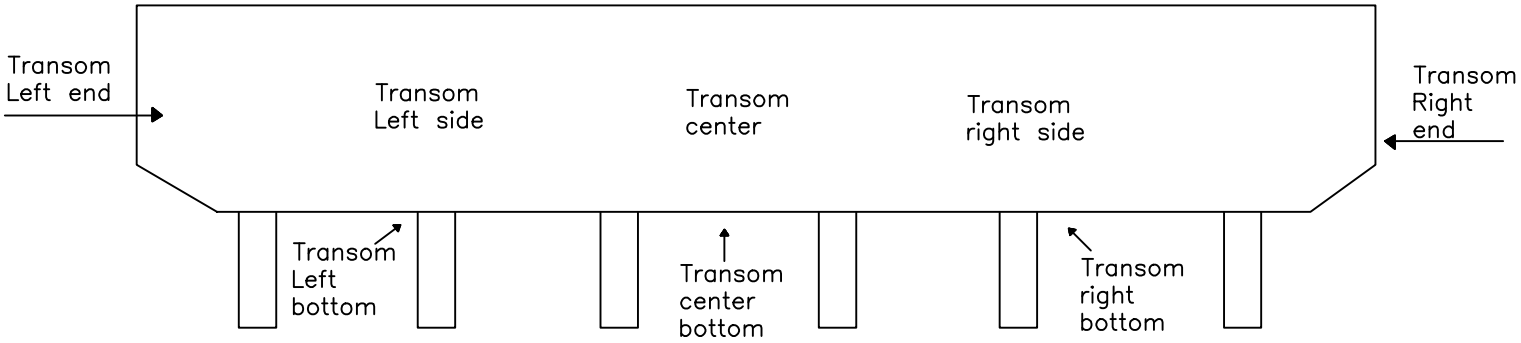
APPROVED BY :

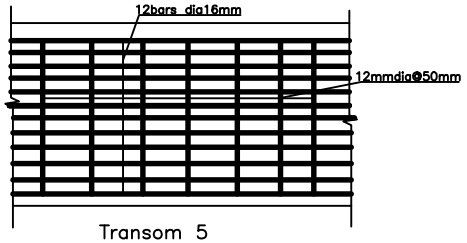
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

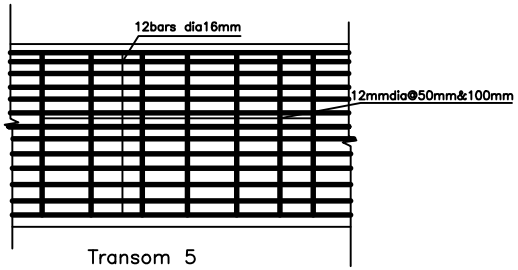
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

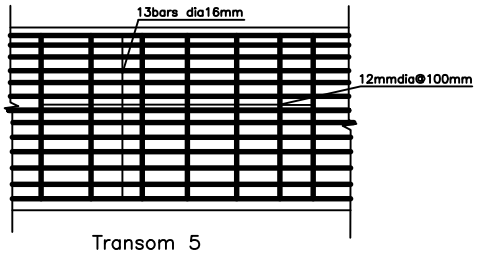




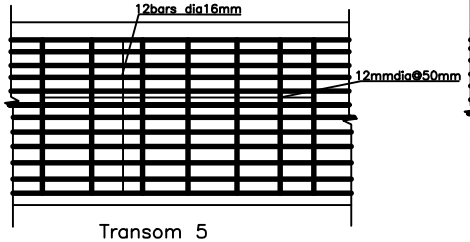
Transom 5
Left side front
Concrete cover35mm



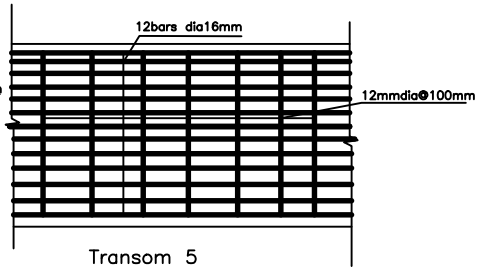
Transom 5
Center front
Concrete cover 32mm



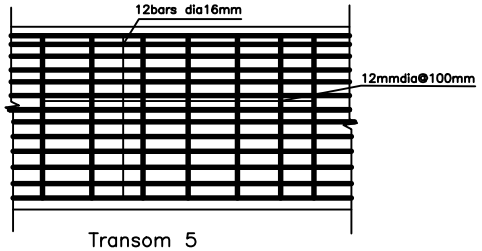
Transom 5
Right end front
Concrete cover 40mm



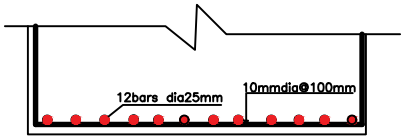
Transom 5
Left side back
Concrete cover35mm



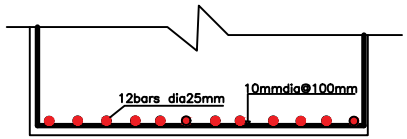
Transom 5
Center back
Concrete cover 40mm



Transom 5
Right end back
Concrete cover 35mm



Transom 5
Left side bottom
Concrete cover 45mm



Transom 5
Center bottom
Concrete cover 40mm

No.s	Identification	No of scans
1	Transom 5 right end front	2 scan
2	Transom 5 right end back	2 scan
3	Transom 5 Center front	2 scan
4	Transom 5 Center back	2 scan
5	Transom 5 Center bottom	2 scan
6	Transom 5 left side front	2 scan
7	Transom 5 left side back	2 scan
8	Transom 5 left side bottom	2 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

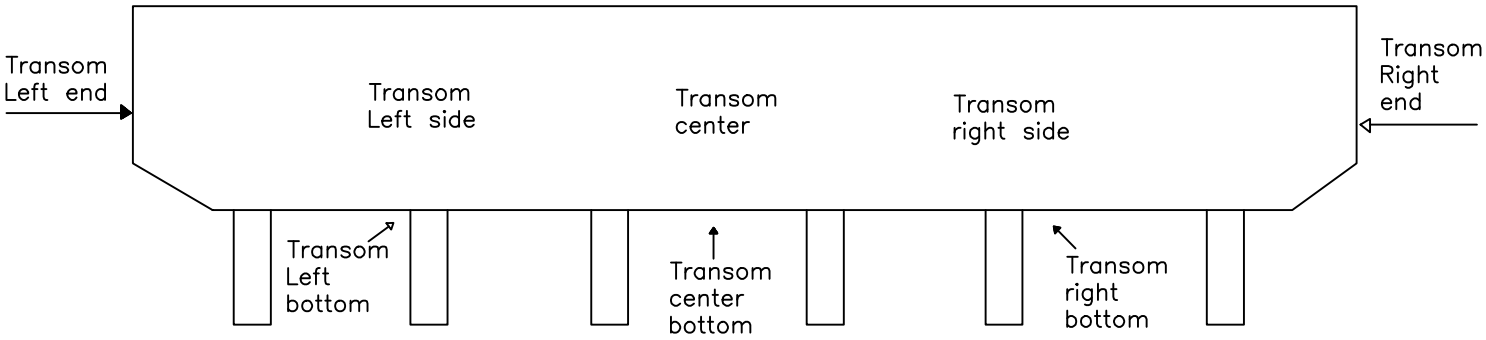
APPROVED BY :

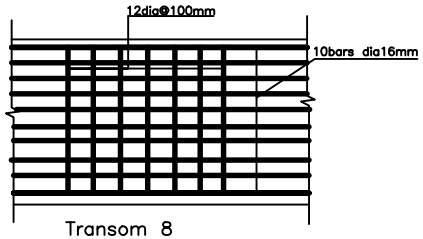
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

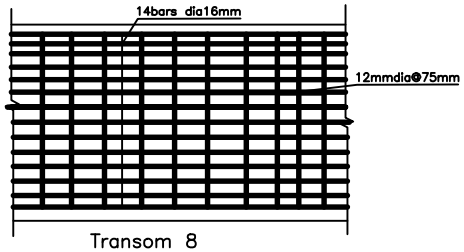
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

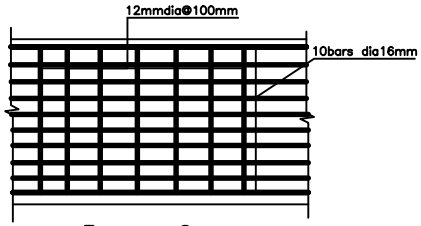




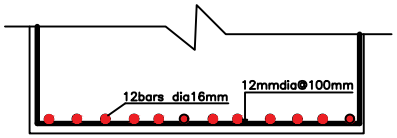
Transom 8
Right end
Concrete cover 38mm



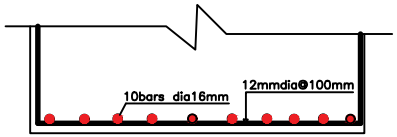
Transom 8
Center front
Concrete cover 40mm



Transom 8
Right side front
Concrete cover 35mm



Transom 8
Center bottom
Concrete cover 32mm



Transom 8
Right side bottom
Concrete cover 32mm

No.s	Identification	No of scans
1	Transom 8 right side front	2 scan
2	Transom 8 right side bottom	2 scan
3	Transom 8 Center front	2 scan
4	Transom 8 Center bottom	2 scan
5	Transom 8 right end	2 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:
Scanning Section

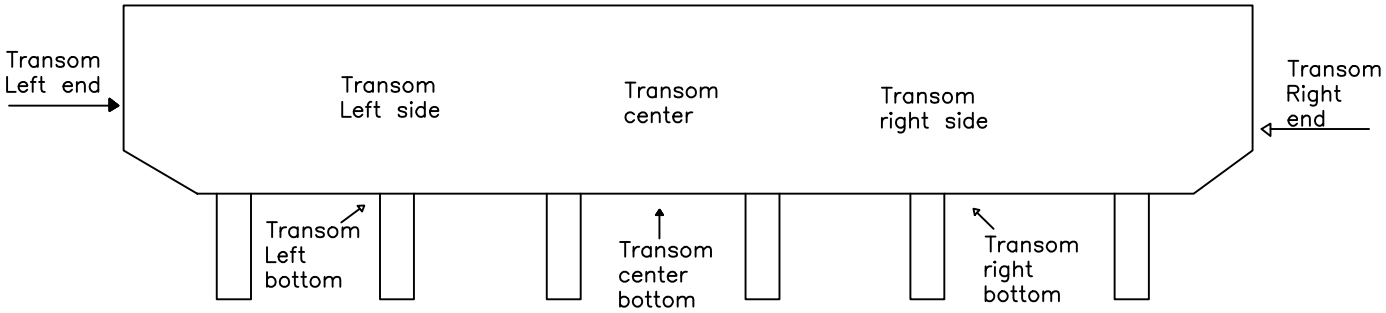
DRAWN BY : ENGR RAHEEL SHAIKH

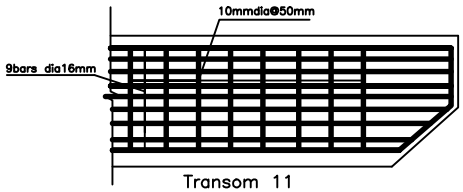
APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

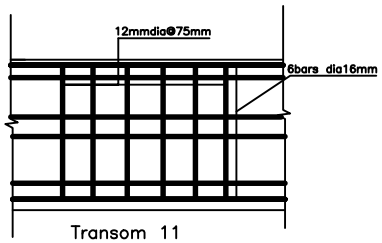
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

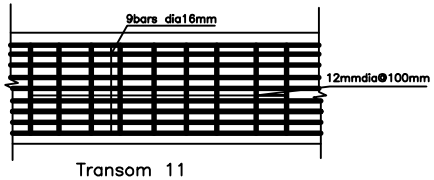




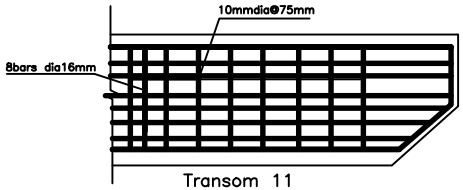
Transom 11
Right side end front
Concrete cover 35mm



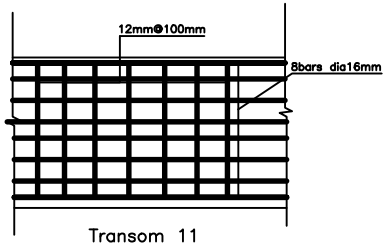
Transom 11
Center front
Concrete cover 45mm



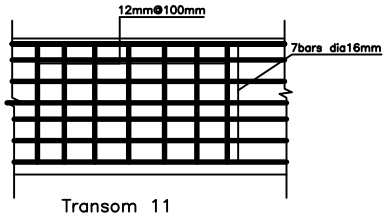
Transom 11
Right side front
Concrete cover 25mm



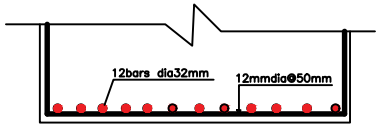
Transom 11
Right side end back
Concrete cover 45mm



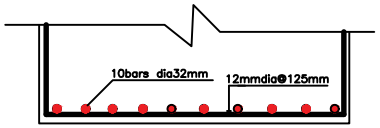
Transom 11
Center back
Concrete cover 45mm



Transom 11
Right side back
Concrete cover 42mm



Transom 11
Center bottom
concrete cover 45mm



Transom 11
Right side bottom
Concrete cover 45mm

No.s	Identification	No of scans
1	Transom 11 right side front	2 scan
2	Transom 11 right side back	2 scan
3	Transom 11 right side bottom	2 scan
4	Transom 11 Center front	2 scan
5	Transom 11 Center back	2 scan
6	Transom 11 Center bottom	2 scan
7	Transom 11 right side end front	2 scan
8	Transom 11 right side end back	2 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: JO1-0003-10/21

DRAWING TITLE:
Scanning Section

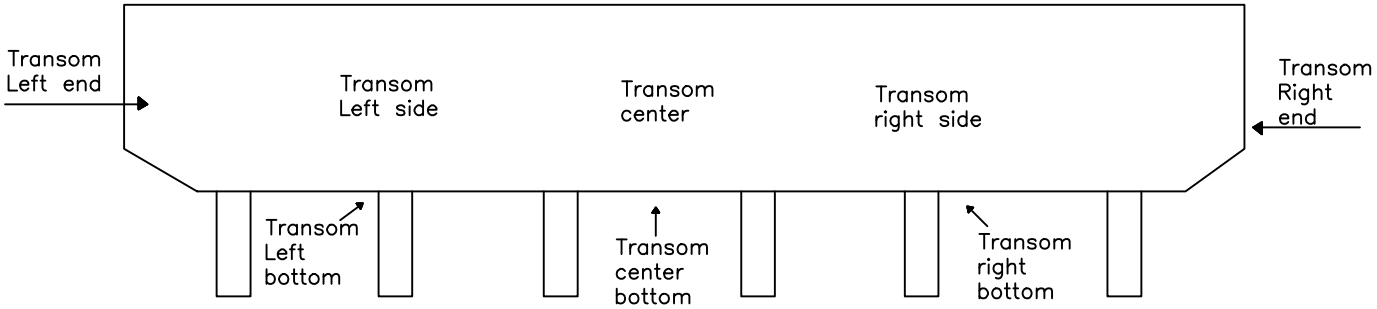
DRAWN BY : ENGR RAHEEL SHAIKH

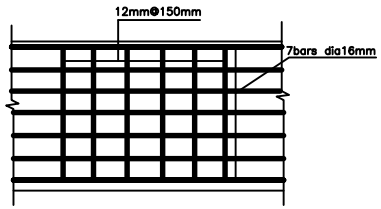
APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

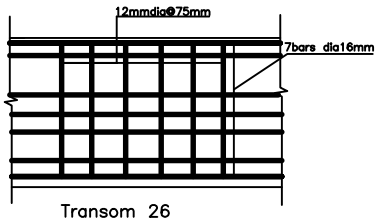
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

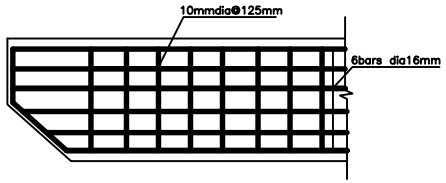




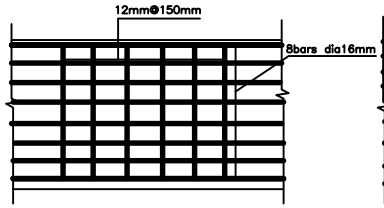
Transom 26
left side front
Concrete cover 65mm



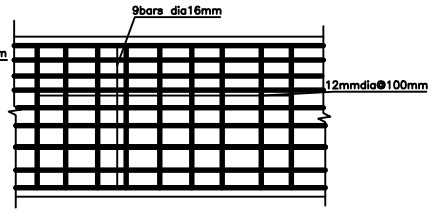
Transom 26
Center front
Concrete cover 40mm



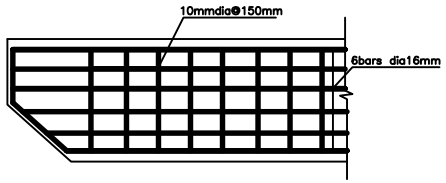
Transom 26
left end front
Concrete cover 30mm



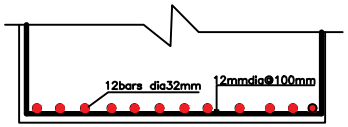
Transom 26
left side back
Concrete cover 50mm



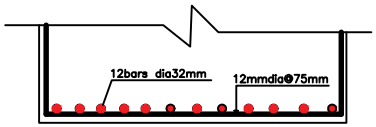
Transom 26
Center Back
Concrete cover 25mm



Transom 26
left end back
Concrete cover 35mm



Transom 26
left side bottom
Concrete cover 45mm



Transom 26
Center bottom
concrete cover 40mm

No.s	Identification	No of scans
1	Transom 26 left end front	2 scan
2	Transom 26 left end back	2 scan
3	Transom 26 Center front	2 scan
4	Transom 26 Center back	2 scan
5	Transom 26 Center bottom	2 scan
6	Transom 26 left side front	2 scan
7	Transom 26 left side back	2 scan
8	Transom 26 left side bottom	2 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: JO1-0003-10/21

DRAWING TITLE:
Scanning Section

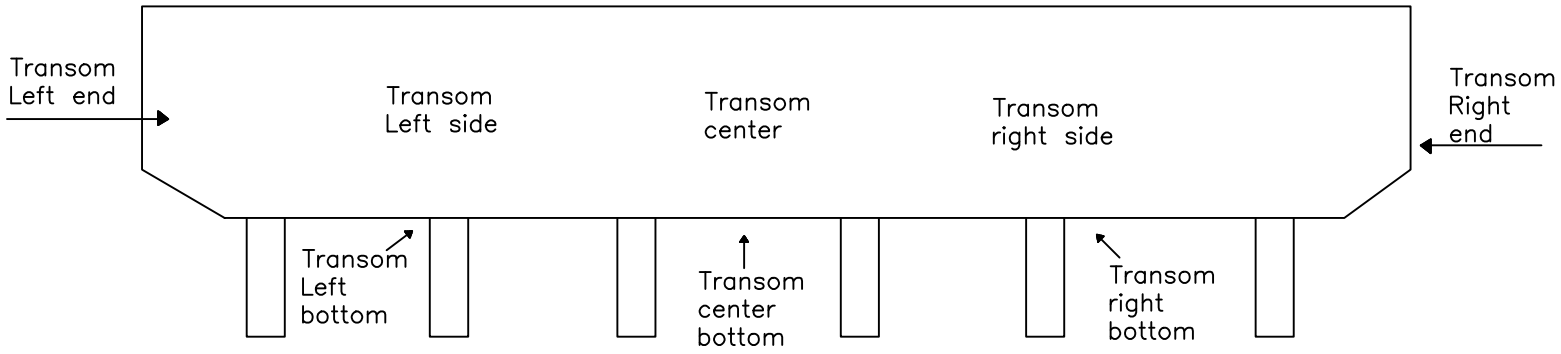
DRAWN BY : ENGR RAHEEL SHAIKH

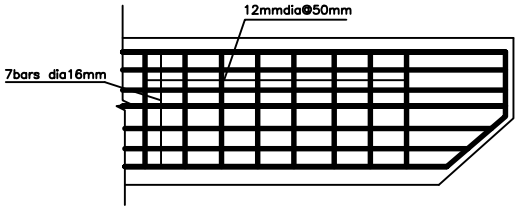
APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

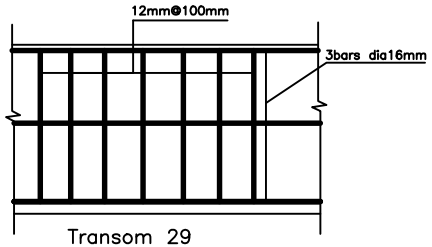
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

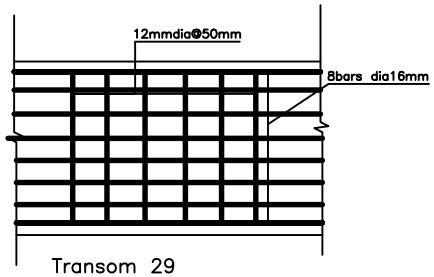




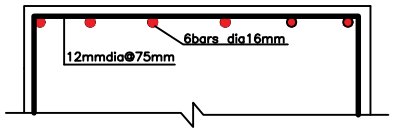
Transom 29
Right end
Concrete cover 30mm



Transom 29
Center
Concrete cover 40mm



Transom 29
Right side
Concrete cover 40mm



Transom 29
Right end top
concrete cover 38mm

No.s	Identification	No of scans
1	Transom 29 right side	2 scan
2	Transom 29 Center	2 scan
3	Transom 29 right end	2 scan
4	Transom 29 right end top	2 scan

Date	Description	APPR

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

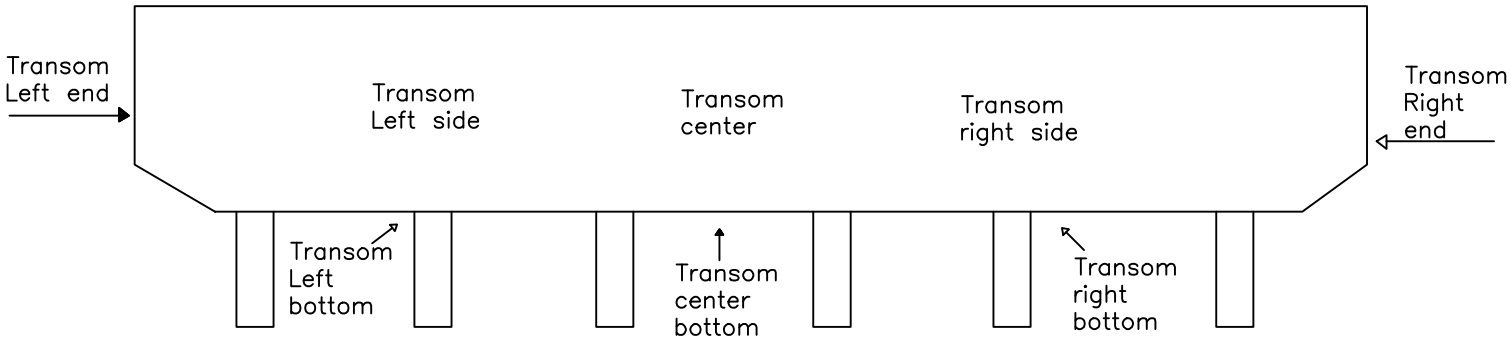
APPROVED BY :

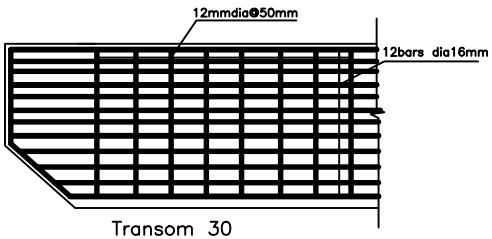
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

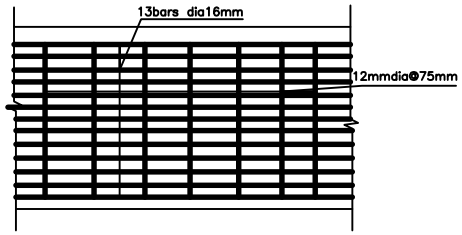
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

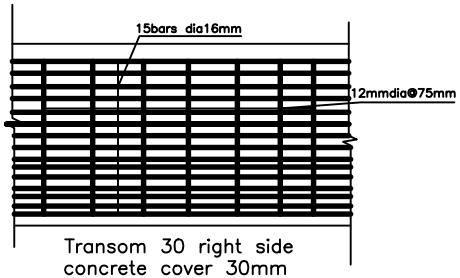




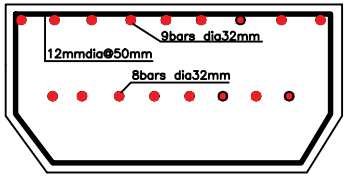
Transom 30
Left End
Concrete cover 30mm



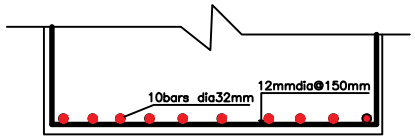
Transom 30 center
concrete cover 33mm



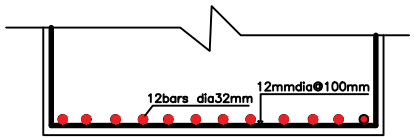
Transom 30 right side
concrete cover 30mm



Transom 30
Left end
top & end face
concrete cover 35mm



Transom 30
Center bottom
concrete cover 35mm



Transom 30
right side bottom
concrete cover 30mm

No.s	Identification	No of scans
1	Transom 30 right side	2 scan
2	Transom 30 R.S.bottom	2 scan
3	Transom 30 center	2 scan
4	Transom 30 center bottom	2 scan
5	Transom 30 left end	2 scan
6	Transom 30 left end top and end face	4 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:
Scanning Section

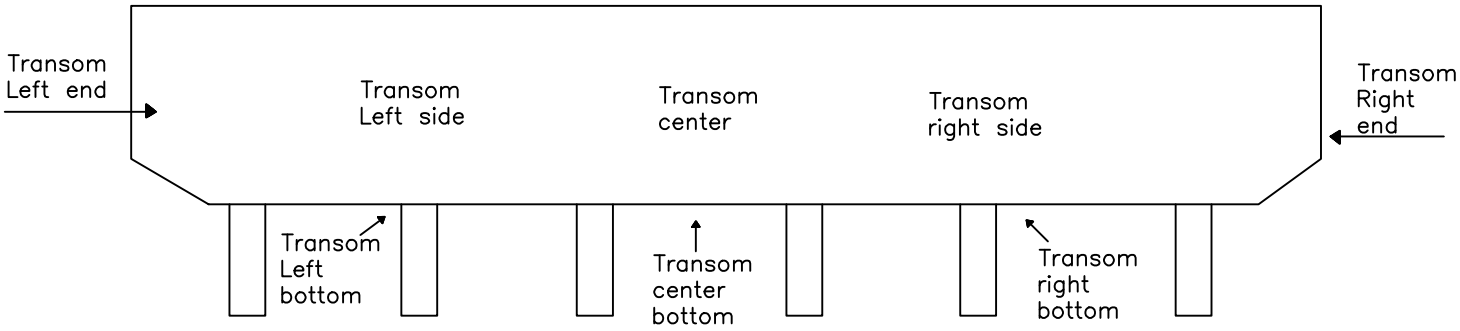
DRAWN BY : ENGR RAHEEL SHAIKH

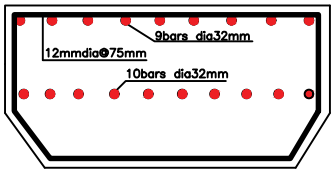
APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

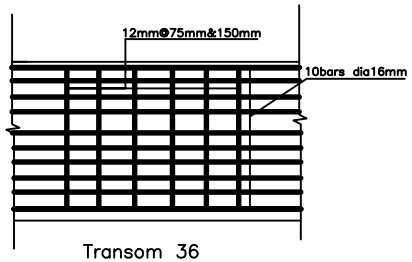
Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

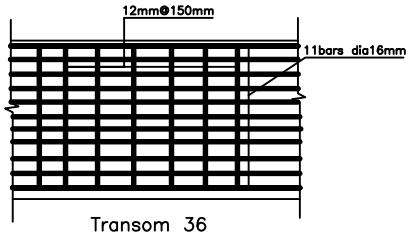




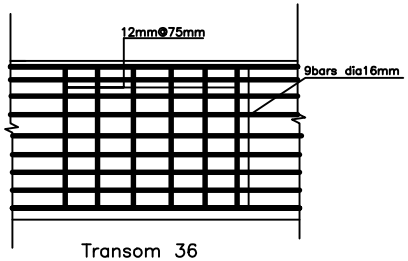
Transom 36
Right end
top & end face
concrete cover 45and35mm



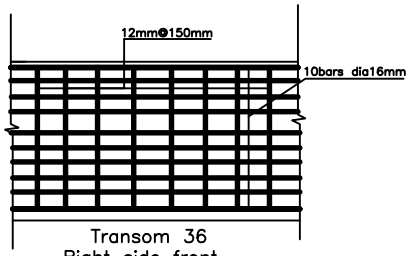
Transom 36
Center back
Concrete cover 45mm



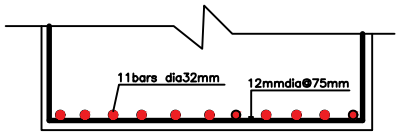
Transom 36
Right side back
Concrete cover 55mm



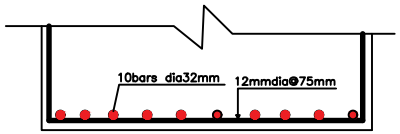
Transom 36
Center front
Concrete cover 40mm



Transom 36
Right side front
Concrete cover 45mm



Transom 36
Center bottom
concrete cover 50mm



Transom 36
Right side bottom
concrete cover 35mm

No.s	Identification	No of scans
1	Transom 36 right side back	2 scan
2	Transom 36 right side front	2 scan
3	Transom 36 right side bottom	2 scan
4	Transom 36 Center back	2 scan
5	Transom 36 Center front	2 scan
6	Transom 36 Center bottom	2 scan
7	Transom 36 right top and end face	4 scan

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:
Scanning Section

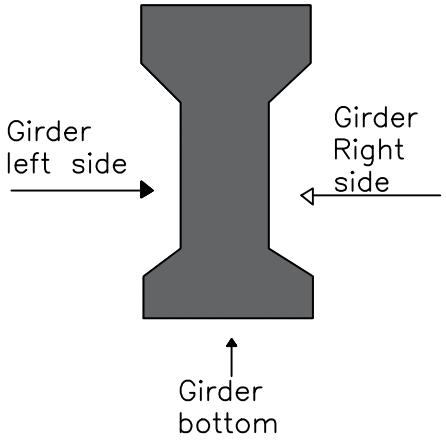
DRAWN BY : ENGR RAHEEL SHAIKH

APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

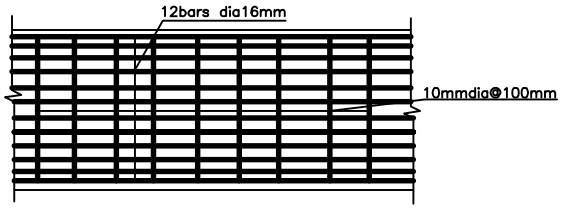
DATE : 21/Oct/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

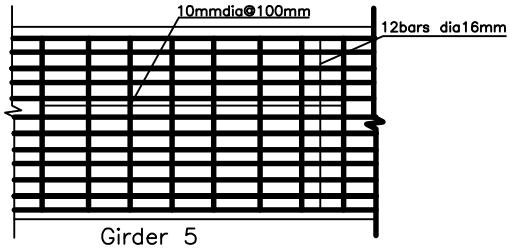
Drawing No:	Revision
S-01	0-0



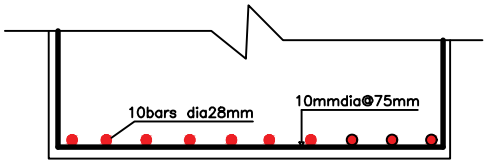
No.s	Identification	No of scans
1	Girder 5 right side	2 scan
2	Girder 5 left side	2 scan
3	Girder 5 Bottom	2 scan
4	Girder 5 left side	2 scan
5	Girder 5 right side	2 scan
6	Girder 5 Bottom	2 scan
	Total	12 scan



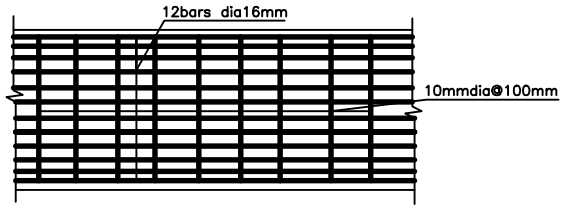
Girder 5 center
Right side
Concrete cover 37mm



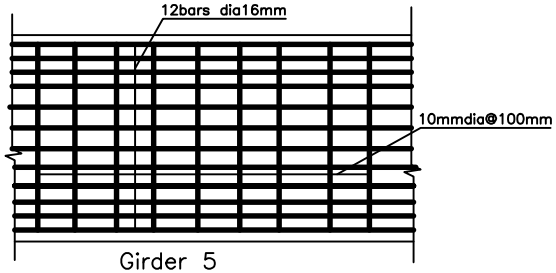
Girder 5
Right side
Concrete Cover 37mm



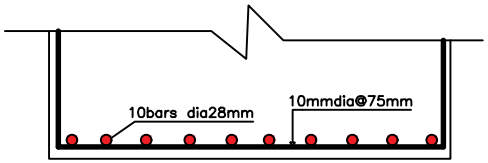
Girder 5 center
Bottom
Concrete cover 35mm



Girder 5 center
Left side
Concrete cover 40mm



Girder 5
Left side
Concrete cover 38mm



Girder 5
Bottom
Concrete cover 30mm

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

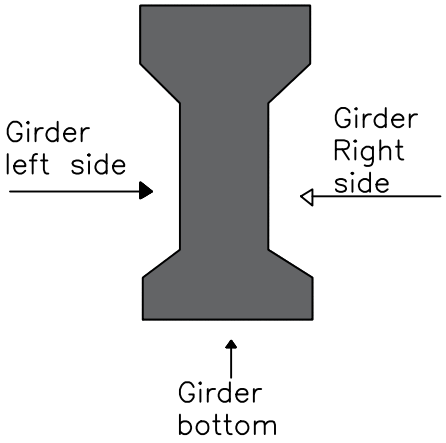
APPROVED BY :

ENGR.MUHAMMAD IMRAN ARIF

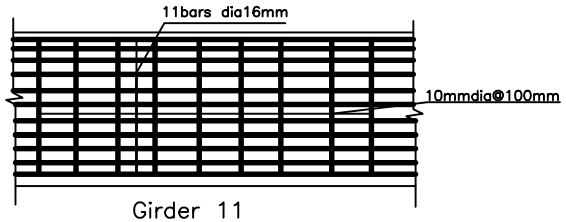
DATE : 3/Nov/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

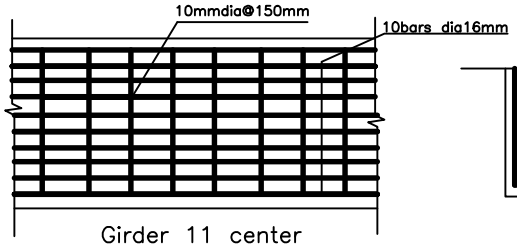
Drawing No:	Revision
S-01	0-0



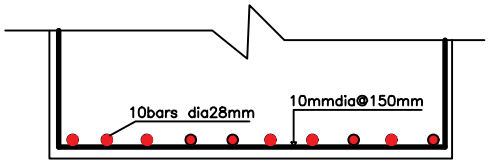
No.s	Identification	No of scans
1	Girder 11 right side	2 scan
2	Girder 11 left side	2 scan
3	Girder 11 Bottom	2 scan
4	Girder 11 left side	2 scan
5	Girder 11 right side	2 scan
6	Girder 11 Bottom	2 scan
	Total	12 scan



Girder 11
Right side
Concrete cover 55mm



Girder 11 center
Right side
Concrete Cover 45mm



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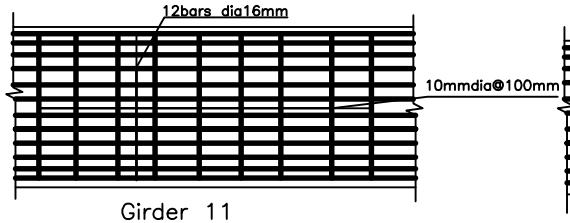
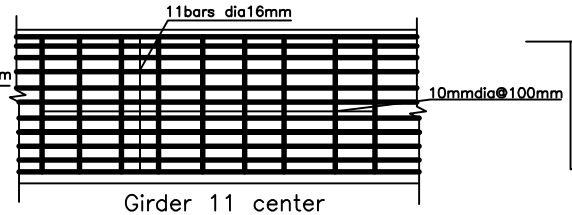
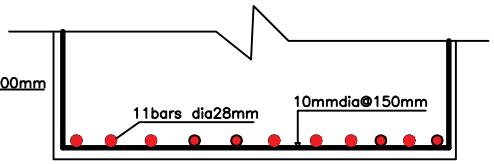
Bottom
Concrete cover 36mm



Girder 11
Left side
Concrete cover 40mm



Girder 11 center
Left side
Concrete cover 40mm



Girder 11
Bottom
Concrete cover 36mm

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

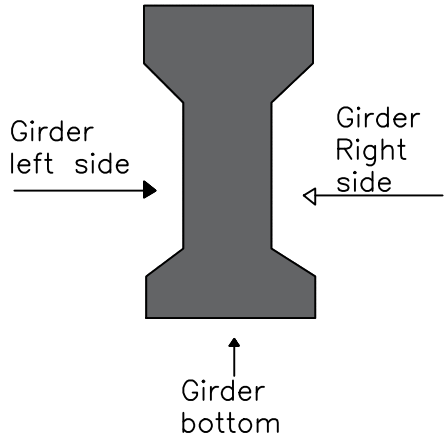
APPROVED BY :

ENGR.MUHAMMAD IMRAN ARIF

DATE : 21/Oct/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0



No.s	Identification	No of scans
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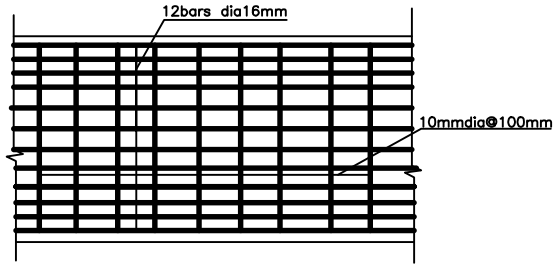
2	Girder 26 left side	2 scan
3	Girder 26 Bottom	2 scan
4	Girder 26 left side	2 scan
5	Girder 26 right side	2 scan
6	Girder 26 Bottom	2 scan
	Total	12 scan



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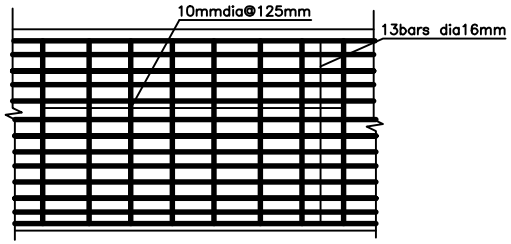
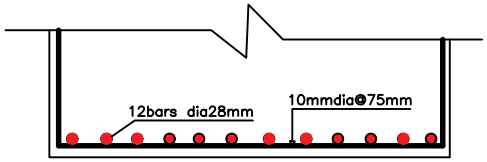
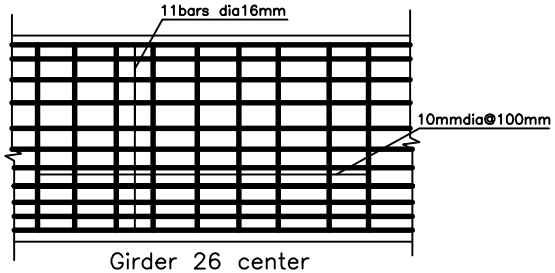
Right side
Concrete cover 37mm



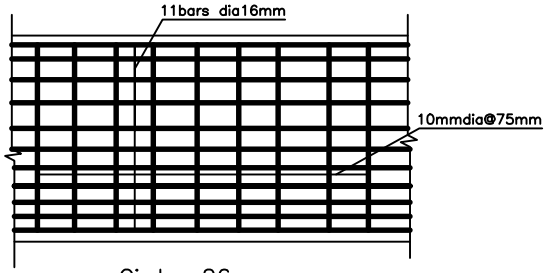
Girder 26
Right side
Concrete Cover 40mm



Girder 26
Bottom
Concrete cover 35mm



Girder 26 center
Left side
Concrete cover 40mm



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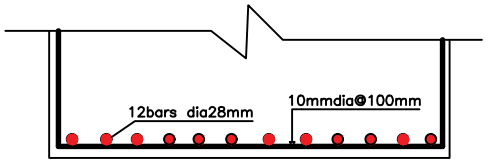
Left side
Concrete cover 76mm



Girder 26 center
Bottom
Concrete cover 40mm

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: JO1-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

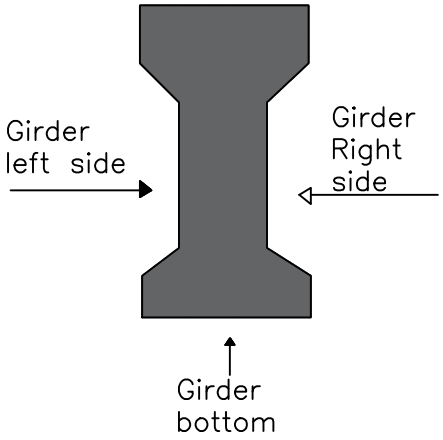
APPROVED BY :

ENGR.MUHAMMAD IMRAN ARIF

DATE : 3/Nov/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0



No.s	Identification	No of scans
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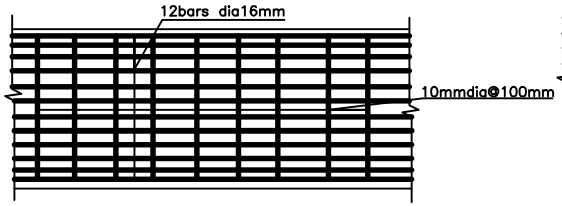
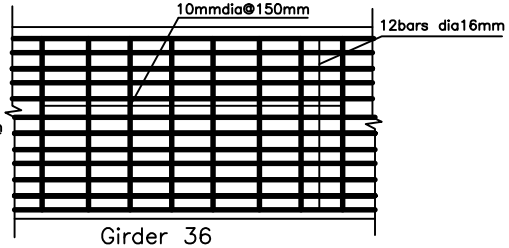
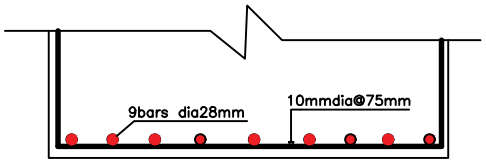
2	Girder 36 left side	2 scan
3	Girder 36 Bottom	2 scan
4	Girder 36 left side	2 scan
5	Girder 36 right side	2 scan
6	Girder 36 Bottom	2 scan
	Total	12 scan



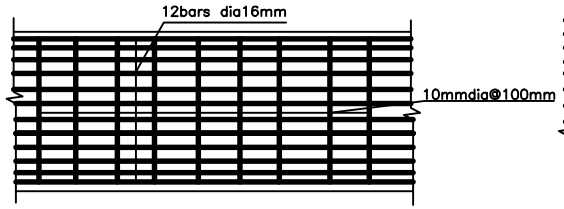
Girder 36 center
Right side
Concrete cover 55mm



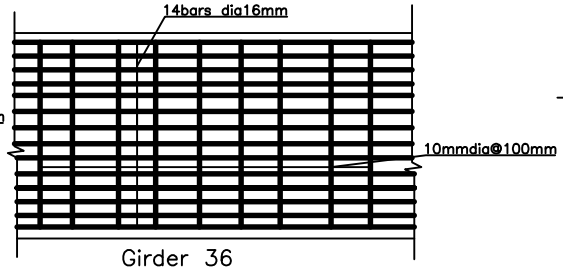
Girder 36
Right side
Concrete Cover 35mm



Girder 36 center
Bottom
Concrete cover 30mm



Girder 36 center
Left side
Concrete cover 40mm



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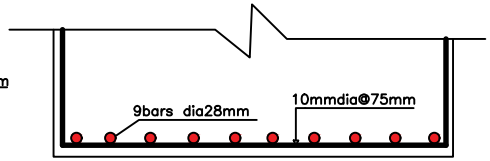
Left side
Concrete cover 30mm



Girder 36
Bottom
Concrete cover 30mm

Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE:

Scanning Section

DRAWN BY : ENGR RAHEEL SHAIKH

APPROVED BY :

ENGR.MUHAMMAD IMRAN ARIF

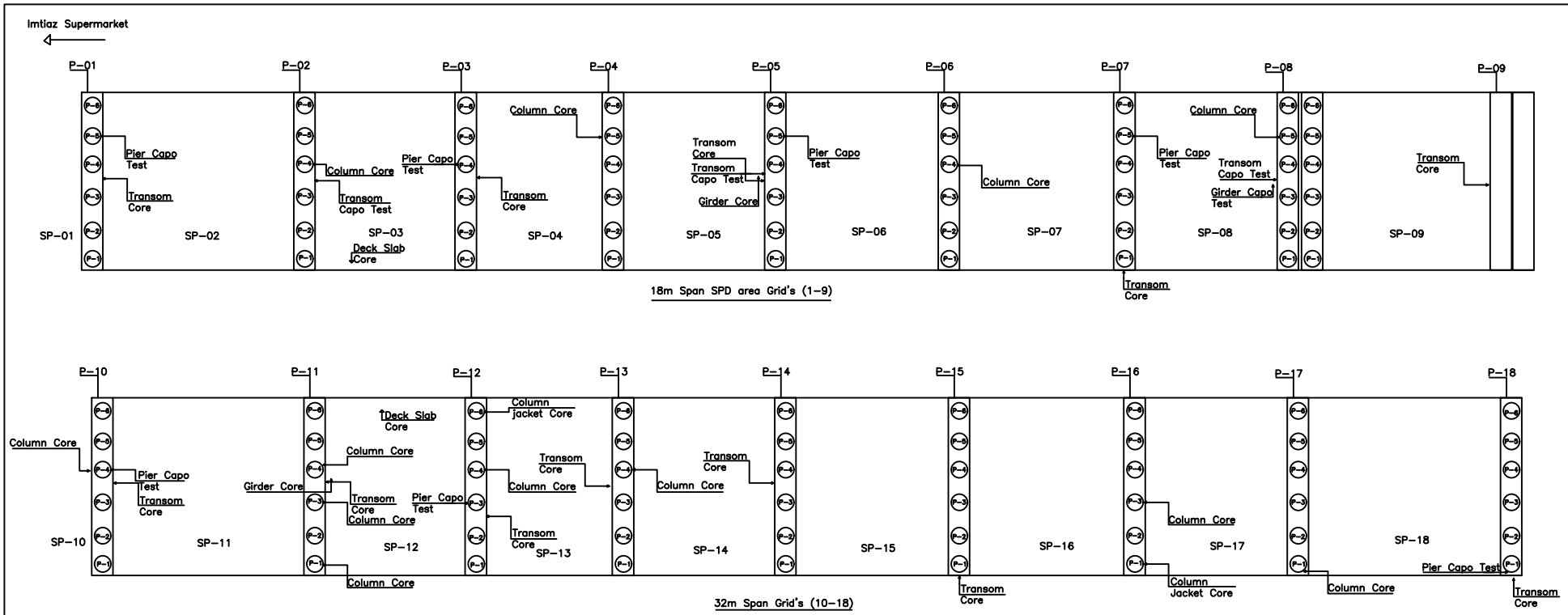
DATE : 3/Nov/2021

Drawing status
AS BUILT REBAR SCANNING DRAWING

Drawing No:	Revision
S-01	0-0

APPENDIX C – CORE EXTRACTION AND COMPRESSIVE STRENGTH TEST RESULTS

This document is issued by the F&M Engineering, Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that Information contained hereon reflects the Company's findings at the time of inspection only and within the limits of Client's instructions, if any



Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: J01-0003-10/21

DRAWING TITLE
Marking of Core and Capo test

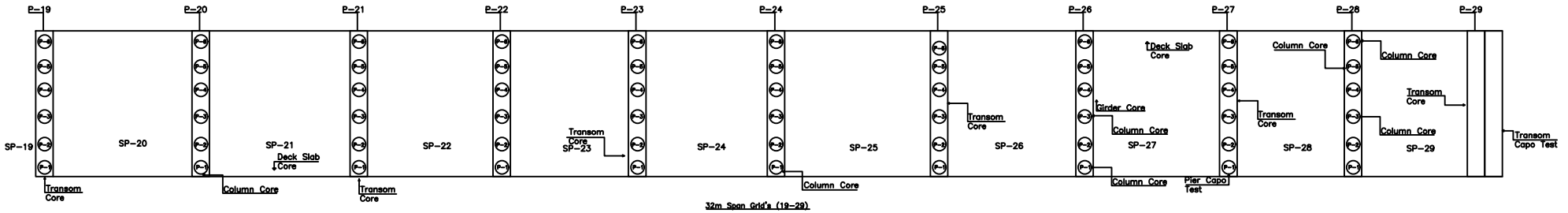
DRAWN BY : ENGR RAHEEL SHAIKH

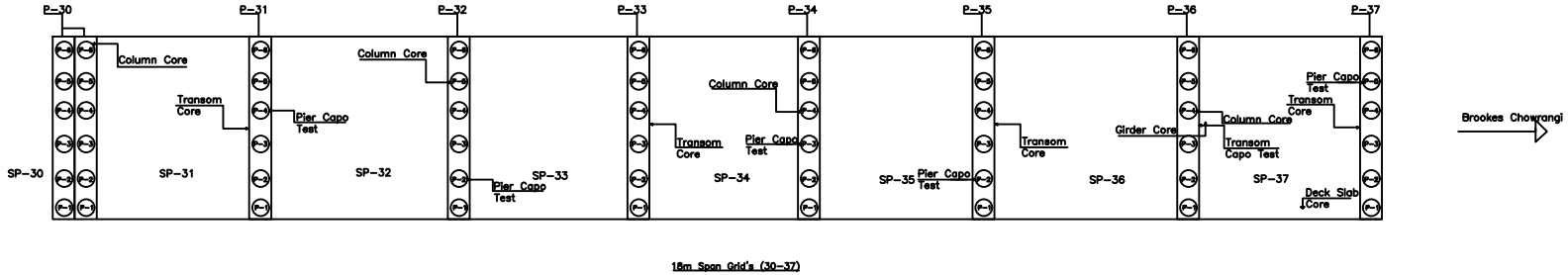
APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 5/Nov/2021

Drawing status
AS BUILT OF CORE AND CAPO MARKING

Drawing No:	Revision
S-01	0-0





Date	Description	APPR

F&M ENGINEERING

PLOT NO. B-227, BLOCK 13-D-1
GULSHAN-E-IQBAL,KARACHI, PAKISTAN
TEL:021-34973000/021-33328208

Job No: JO1-0003-10/21

DRAWING TITLE
Marking of Core and Capo Test

DRAWN BY : ENGR RAHEEL SHAIKH

APPROVED BY :
ENGR.MUHAMMAD IMRAN ARIF

DATE : 5/Nov/2021

Drawing status
AS BUILT OF CORE AND CAPO MARKING

Drawing No:	Revision
S-01	0-0

F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20 & ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number** :	J01-0003-10/21
Client :	Nespak	**Date of issue** :	16-11- 2021
Location :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
1	Transom 01, Core 52	3.23	6.73	2.09	52.83	8.19	2.305	11/11/2021	116	1.00	224	3179	21.93	Type 2
2	Transom 03, Core 48	2.20	4.37	1.98	24.64	3.82	2.318	11/11/2021	54	1.00	223	3173	21.88	Type 2
3	Transom 05, Core 45	3.23	5.47	1.70	52.83	8.19	2.267	11/11/2021	103	0.98	195	2767	19.08	Type 3
4	Transom 07, Core 50	2.20	4.00	1.81	24.64	3.82	2.247	11/11/2021	35	1.00	145	2057	14.18	Type 3
5	Transom 09 Core 51	2.17	4.33	2.00	23.77	3.68	2.276	11/11/2021	24	1.00	103	1462	10.08	Type 2
6	Transom 10, Core#01	2.95	3.23	1.09	44.20	6.85	2.235	11/11/2021	93	0.87	187	2651	18.28	Type 2

Reviewed by:	Checked by:
Lab Assistant: Asad Raza/ Safana Shafiq	**Lab Manager:Jawwad Naseem**

F & M Engineering
Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal, Karachi
Tel : 021-34973000 / 021-33328208 queries@fnmengineering.com / www.fnmengineering.com

F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number** :	J01-0003-10/21
Client :	Nespak	**Date of issue** :	16-11- 2021
Location :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
7	Transom 11, Core#03 ©	2.95	5.60	1.90	44.20	6.85	2.482	11/11/2021	92	1.00	212	3014	20.79	Type 2
8	Transom 12, Core # 06	2.20	3.90	1.77	24.64	3.82	2.275	11/11/2021	89	1.00	368	5230	36.07	Type 3
9	Transom 13, Core#07 ©	2.20	4.13	1.88	24.64	3.82	2.454	11/11/2021	30	1.00	124	1763	12.16	Type 5
10	Transom 14, Core #09	2.91	4.76	1.64	43.03	6.67	2.401	11/11/2021	68	0.98	158	2243	15.47	Type 2
11	Transom 15, Core #11	2.95	4.25	1.44	44.20	6.85	2.292	11/11/2021	76	0.96	168	2390	16.49	Type 3
12	Transom 18, Core#13	2.20	4.02	1.82	24.64	3.82	2.395	11/11/2021	44	1.00	182	2586	17.83	Type 3

Reviewed by:	Checked by:
	F & M ENGINEERING KARACHI
Lab Assistant: Asad Raza/ Safana Shafiq	Lab Manager:Jawwad Naseem

F & M Engineering
Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal, Karachi
Tel : 021-34973000 / 021-33328208 queries@fnmengineering.com / www.fnmengineering.com

F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project	: Jam Sadiq Bridge	**Job Number** :	J01-0003-10/21
Client	: Nespak	**Date of issue** :	16-11- 2021
Location	: Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
13	Transom 19, Core#14	2.95	5.08	1.72	44.20	6.85	2.235	11/11/2021	61	0.98	138	1959	13.51	Type 2
14	Transom 21, Core#21	2.91	5.04	1.73	43.03	6.67	2.164	11/11/2021	130	0.98	302	4287	29.57	Type 3
15	Transom 23 Core#22	2.95	4.84	1.64	44.20	6.85	2.355	11/11/2021	128	0.98	289	4110	28.34	Type 2
16	Transom 25, Core#24	2.91	4.80	1.65	43.03	6.67	2.494	11/11/2021	138	0.98	321	4551	31.39	Type 2
17	Transom 27, Core #26	2.99	4.25	1.42	45.38	7.03	2.183	11/11/2021	95	0.96	205	2910	20.07	Type 3
18	Transom 29, Core#24	2.95	5.91	2.00	44.20	6.85	2.261	11/11/2021	46	1.00	106	1507	10.39	Type 3

Reviewed by:	Checked by:
	F&M ENGINEERING KARACHI
Lab Assistant: Asad Raza/ Safana Shafiq	Lab Manager: Jawwad Naseem

F & M Engineering
Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal, Karachi
Tel : 021-34973000 / 021-33328208 queries@fnmengineering.com / www.fnmengineering.com

F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number :**	J01-0003-10/21
Client :	Nespak	**Date of issue :**	16-11-2021
Locatic :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
19	Transom 31, Core #30	3.23	6.10	1.89	52.83	8.19	2.352	11/11/2021	83	1.00	160	2275	15.69	Type 2
20	Transom 33, Core#32	3.23	5.31	1.65	52.83	8.19	2.351	11/11/2021	163	0.98	308	4378	30.19	Type 2
21	Transom 35, Core#34	3.23	6.42	1.99	52.83	8.19	2.268	11/11/2021	140	1.00	270	3837	26.46	Type 2
22	Transom 37, Core#36	3.23	5.20	1.61	52.83	8.19	2.326	11/11/2021	111	0.98	210	2981	20.56	Type 2
23	Pier 2 Core #55	2.20	4.01	1.82	24.64	3.82	2.213	11/11/2021	45	1.00	186	2644	18.24	Type 2
24	Pier 04 Core # 49	2.95	2.95	1.00	44.20	6.85	2.172	11/11/2021	136	0.87	273	3876	26.73	Type 2

Reviewed by:	Checked by:
	F&M ENGINEERING KARACHI
Lab Assistant: Asad Raza/ Safana Shafiq	Lab Manager:Jawwad Naseem

F & M Engineering
Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal, Karachi
Tel : 021-34973000 / 021-33328208 queries@fnmengineering.com / www.fnmengineering.com

F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number :**	J01-0003-10/21
Client :	Nespak	**Date of issue :**	16-11-2021
Locatio :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
25	Pier 06 Core # 46	2.95	2.95	1.00	44.20	6.85	2.429	11/11/2021	126	0.87	253	3591	24.77	Type 2
26	Pier 08, Core # 41	2.20	2.83	1.29	24.64	3.82	2.255	11/11/2021	69	0.96	274	3893	26.85	Type 2
27	Pier 10, Core # 02	2.24	3.62	1.61	25.53	3.96	2.470	11/11/2021	83	0.98	325	4614	31.82	Type 2
28	Pier 11 (06), Core # 56	2.20	2.28	1.04	24.64	3.82	2.274	11/11/2021	91	0.87	328	4652	32.09	Type 2
29	Pier 11 (05), Core # 57	2.20	2.28	1.04	24.64	3.82	2.204	11/11/2021	73	0.87	263	3732	25.74	Type 3
30	Pier 11 Core #04	2.20	4.37	1.98	24.64	3.82	2.282	11/11/2021	24	1.00	99	1410	9.73	Type 3

Reviewed by:	Checked by:
	F & M ENGINEERING KARACHI
Lab Assistant: Asad Raza/ Safana Shafiq	Lab Manager: Jawwad Naseem

F & M Engineering
Plot No. B-227, Block 13-D/1, Gulshan-e-Iqbal, Karachi
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F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number :**	J01-0003-10/21
Client :	Nespak	**Date of issue :**	16-11-2021
Locatio :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
31	Pier 12 Core #63 (Jacketing)	2.95	5.91	2.00	44.20	6.85	2.248	11/11/2021	143	1.00	330	4685	32.31	Type 2
32	Pier 12 ©, Core #05	2.20	3.23	1.46	24.64	3.82	2.480	11/11/2021	26	0.96	103	1467	10.12	Type 3
33	Pier 13 Core #08	2.95	2.95	1.00	44.20	6.85	2.202	11/11/2021	62	0.87	124	1767	12.19	Type 3
34	Pier 16 Core #02	3.23	5.16	1.60	52.83	8.19	2.429	11/11/2021	93	0.98	176	2498	17.23	Type 2
35	Pier 16 Jacketing, Core # 58	2.99	4.02	1.34	45.38	7.03	2.268	11/11/2021	115	0.93	240	3412	23.53	Type 2
36	Pier 17 Core #12	2.17	3.07	1.42	23.77	3.68	2.427	11/11/2021	34	0.96	140	1988	13.71	Type 3

Reviewed by:	Checked by:
	F & M ENGINEERING KARACHI
Lab Assistant: Asad Raza/ Safana Shafiq	Lab Manager:Jawwad Naseem

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COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number :**	J01-0003-10/21
Client :	Nespak	**Date of issue :**	16-11- 2021
Locatic :	Jam Sadiq Bridge		-

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S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
37	Pier 20 Core #20	2.20	3.98	1.80	24.64	3.82	2.122	11/11/2021	24	1.00	99	1410	9.73	Type 3
38	Pier 22 Core #15	2.95	2.95	1.00	44.20	6.85	2.353	11/11/2021	124	0.87	249	3534	24.38	Type 2
39	Pier 24 Core #23	2.91	5.98	2.05	43.03	6.67	2.324	11/11/2021	36	1.00	85	1212	8.36	Type 3
40	Pier 26 Core #28	3.23	5.28	1.63	52.83	8.19	2.308	11/11/2021	170	0.98	322	4566	31.49	Type 2
41	Pier 26, Core # 29	2.24	4.02	1.79	25.53	3.96	2.420	11/11/2021	63	1.00	252	3573	24.64	Type 2
42	Pier 28 Core #44 ©	2.20	3.94	1.79	24.64	3.82	2.434	11/11/2021	44	1.00	182	2586	17.83	Type 3

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COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number :**	J01-0003-10/21
Client :	Nespak	**Date of issue :**	16-11- 2021
Locatic :	Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
43	Pier 28, Core # 54	2.24	3.86	1.72	25.53	3.96	2.278	11/11/2021	55	0.98	215	3057	21.08	Type 4
44	Pier 30 Core #27	2.95	2.95	1.00	44.20	6.85	2.323	11/11/2021	127	0.87	255	3620	24.96	Type 3
45	Pier 32 Core #31	2.95	2.95	1.00	44.20	6.85	2.187	11/11/2021	130	0.87	261	3705	25.55	Type 3
46	Pier 34 Core #33	2.24	4.02	1.79	25.53	3.96	2.496	11/11/2021	130	1.00	519	7374	50.85	Type 3
47	Pier 34, Core #39	2.20	3.94	1.79	24.64	3.82	2.334	11/11/2021	26	1.00	108	1528	10.54	Type 3
48	Pier 36 Core #35	2.24	3.43	1.53	25.53	3.96	2.408	11/11/2021	33	0.96	127	1797	12.39	Type 3

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F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project	: Jam Sadiq Bridge	**Job Number** :	J01-0003-10/21
Client	: Nespak	**Date of issue** :	16-11-2021
Location	: Jam Sadiq Bridge		-

-

S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
49	Girder 05 Core#47	2.95	2.95	1.00	44.20	6.85	2.187	11/11/2021	93	0.87	187	2651	18.28	Type 3
50	Girder 11 Core#60	2.24	4.02	1.79	25.53	3.96	2.220	11/11/2021	73	1.00	292	4141	28.56	Type 3
51	Girder 26 Core#43	2.20	3.23	1.46	24.64	3.82	2.321	11/11/2021	41	0.98	166	2361	16.28	Type 3
52	Girder 36 Core#37	2.20	3.90	1.77	24.64	3.82	2.275	11/11/2021	28	1.00	116	1645	11.35	Type 5
53	Deck Grid 3 Core#42	2.20	3.11	1.41	24.64	3.82	2.209	11/11/2021	31	0.96	123	1749	12.06	Type 3
54	Deck slab Grid 11 Core #40	2.20	3.70	1.68	24.64	3.82	2.232	11/11/2021	53	0.98	215	3052	21.05	Type 5

Reviewed by:	Checked by:
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F&M ENGINEERING

COMPRESSIVE STRENGTH OF CONCRETE CORE (ASTM C 42/C 42M-20&ASTM C 39)

Project :	Jam Sadiq Bridge	**Job Number** :	J01-0003-10/21
Client :	Nespak	**Date of issue** :	16-11- 2021
Location :	Jam Sadiq Bridge		-

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S.NO.	MARKINGS							Date of Testing	COMPRESSIVE STRENGTH					
	Specimen	Diameter (inch)	Height (inch)	L/D Ratio	Area (cm^2)	Area ($inch^2$)	Density (gm/cc)		Axial Load (KN)	Correction Factor	Strength (Kg/cm^2)	Strength (Psi)	Strength (N/mm^2)	Type of Fracture
55	Deck Grid 19 ©	2.20	3.83	1.74	24.64	3.82	2.150	11/11/2021	31	0.98	126	1785	12.31	Type 3
56	Deck slab Grid 27 Core #40	2.20	2.83	1.29	24.64	3.82	2.255	11/11/2021	44	0.93	169	2405	16.58	Type 3
57	Deck Grid 37 Core #38 ©	2.20	3.62	1.64	24.64	3.82	2.289	11/11/2021	58	0.98	235	3340	23.04	Type 3
58	Abutment (Near Grid 37)	2.99	3.31	1.11	45.38	7.03	2.217	11/11/2021	87	0.87	170	2415	16.65	Type 3

Reviewed by:	Checked by:
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Pictures of Cores after Compressive Strength Test

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APPENDIX D – CAPO TEST

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F&M ENGINEERING	CAPO TEST ASTM C 900-19	Ref: F&M-NESPAK-FOR-JSB Revision: 00 Page 1 of 1

Project	:	Hiring of services for conducting tests at Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	National Engineering Services (Pvt) Limited (NESPAK)	**Date**	:	4-Nov-21
Consultant	:	F&M Engineering	**Source**	:	

S.No	location Identification	Pullout Forces (KN)	Cubical Compressive strength (MPa)	Cubical Compressive strength (PSi)	Estimated Cylinderical Compressive Strength @0.8 times of Cubical Strength (psi)
1	Pier 1	26.6	34.6	5017	4014
2	Pier 7	40.2	54.3	7874	6299
3	Pier 5	15.3	18.7	2712	2169
4	Pier 3	26.8	34.9	5061	4048
5	Pier 10	28.7	37.6	5452	4362
6	Pier 12	14.4	17.5	2538	2030
7	Pier 18	24.8	32.1	4655	3724
8	Pier 31	21.2	27.1	3930	3144
9	Pier 33	22.1	28.4	4118	3294
10	Pier 35	22.3	28.5	4133	3306
11	Pier 37	15.9	19.6	2842	2274
12	Pier 34	23.4	30.1	4365	3492
13	Pier 27	19.7	24.9	3611	2888
14	Transom 8	33.3	44.1	6395	5116
15	Transom 5	23.4	30.1	4365	3492
16	Transom 36	42.5	58.0	8410	6728
17	Transom 29	31.2	41.1	5960	4768
18	Transom 2	32.2	42.5	6163	4930
19	Girder 8	43.9	60.2	8729	6983

Reviewed by:	Approved by:
Lab Assistant : Asad Raza / Safana Shafiq	**Lab Manager : Jawwad Naseem**

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CAPO TEST ASTM C 900-19

S#	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)
1	14.0	13.8	16.7	16.3	16.1	19.9	18.6	18.4	23.4
2	14.1	13.9	16.8	16.4	16.2	20.0	18.7	18.5	23.5
3	14.2	14.0	16.9	16.5	16.3	20.1	18.8	18.6	23.7
4	14.3	14.1	17.1	16.6	16.4	20.3	18.9	18.7	23.8
5	14.4	14.2	17.2	16.7	16.5	20.4	19.0	18.8	24.0
6	14.5	14.3	17.3	16.8	16.6	20.6	19.1	18.9	24.1
7	14.6	14.4	17.5	16.9	16.7	20.7	19.2	19	24.2
8	14.7	14.5	17.6	17.0	16.8	20.9	19.3	19.1	24.4
9	14.8	14.6	17.8	17.1	16.9	21.0	19.4	19.2	24.5
10	14.9	14.7	17.9	17.2	17.0	21.1	19.5	19.3	24.7
11	15.0	14.8	18.0	17.3	17.1	21.3	19.6	19.4	24.8
12	15.1	14.9	18.2	17.4	17.2	21.4	19.7	19.5	24.9
13	15.2	15.0	18.3	17.5	17.3	21.6	19.8	19.6	25.1
14	15.3	15.1	18.5	17.6	17.4	21.7	19.9	19.7	25.2
15	15.4	15.2	18.6	17.7	17.5	21.8	20.0	19.8	25.4
16	15.5	15.3	18.7	17.8	17.6	22.0	20.1	19.9	25.5
17	15.6	15.4	18.9	17.9	17.7	22.1	20.2	20.0	25.7
18	15.7	15.5	19.0	18.0	17.8	22.3	20.3	20.1	25.8
19	15.8	15.6	19.2	18.1	17.9	22.4	20.4	20.2	25.9
20	15.9	15.7	19.3	18.2	18.0	22.5	20.5	20.3	26.1
21	16.0	15.8	19.4	18.3	18.1	22.7	20.6	20.4	26.2
22	16.1	15.9	19.6	18.4	18.2	22.8	20.7	20.5	26.4
23	16.2	16.0	19.7	18.5	18.3	23.0	20.8	20.6	26.5

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CAPO TEST ASTM C 900-19

S#	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)
1	20.7	20.5	26.1	23.0	22.9	29.4	25.3	25.2	32.7
2	20.8	20.6	26.2	23.1	23.0	29.5	25.4	25.3	32.8
3	20.9	20.7	26.4	23.2	23.1	29.7	25.5	25.4	33.0
4	21.0	20.8	26.5	23.3	23.2	29.8	25.6	25.5	33.1
5	21.1	20.9	26.7	23.4	23.3	30.0	25.7	25.6	33.2
6	21.2	21.0	26.8	23.5	23.4	30.1	25.8	25.7	33.4
7	21.3	21.1	26.9	23.6	23.5	30.2	25.9	25.8	33.5
8	21.4	21.2	27.1	23.7	23.6	30.4	26.0	25.9	33.7
9	21.5	21.3	27.2	23.8	23.7	30.5	26.1	26	33.8
10	21.6	21.4	27.4	23.9	23.8	30.7	26.2	26.1	33.9
11	21.7	21.5	27.5	24.0	23.9	30.8	26.3	26.2	34.1
12	21.8	21.6	27.7	24.1	24.0	31.0	26.4	26.3	34.2
13	21.9	21.7	27.8	24.2	24.1	31.1	26.5	26.4	34.4
14	22.0	21.8	27.9	24.3	24.2	31.2	26.6	26.5	34.5
15	22.1	21.9	28.1	24.4	24.3	31.4	26.7	26.6	34.6
16	22.2	22.0	28.2	24.5	24.4	31.5	26.8	26.7	34.8
17	22.3	22.1	28.4	24.6	24.5	31.7	26.9	26.8	34.9
18	22.4	22.3	28.5	24.7	24.6	31.8	27.0	26.9	35.1
19	22.5	22.4	28.7	24.8	24.7	32.0	27.1	27	35.2
20	22.6	22.5	28.8	24.9	24.8	32.1	27.2	27.1	35.4
21	22.7	22.6	29.0	25.0	24.9	32.3	27.3	27.2	35.5
22	22.8	22.7	29.1	25.1	25.0	32.4	27.4	27.3	35.6
23	22.9	22.8	29.2	25.2	25.1	32.5	27.5	27.4	35.8

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S#	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)
1	27.6	27.5	35.9	29.9	29.8	39.2	32.2	32.1	42.3
2	27.7	27.6	36.1	30.0	29.9	39.3	32.3	32.2	42.5
3	27.8	27.7	36.2	30.1	30.0	39.4	32.4	32.3	42.6
4	27.9	27.8	36.3	30.2	30.1	39.6	32.5	32.4	42.8
5	28.0	27.9	36.5	30.3	30.2	39.7	32.6	32.5	42.9
6	28.1	28.0	36.6	30.4	30.3	39.8	32.7	32.5	43.0
7	28.2	28.1	36.8	30.5	30.4	40.0	32.8	32.6	43.2
8	28.3	28.2	36.9	30.6	30.5	40.1	32.9	32.7	43.3
9	28.4	28.3	37.0	30.7	30.6	40.3	33.0	32.8	43.4
10	28.5	28.4	37.2	30.8	30.7	40.4	33.1	32.9	43.6
11	28.6	28.5	37.3	30.9	30.8	40.5	33.2	33.0	43.7
12	28.7	28.6	37.5	31.0	30.9	40.7	33.3	33.1	43.9
13	28.8	28.7	37.6	31.1	31.0	40.8	33.4	33.2	44.0
14	28.9	28.8	37.7	31.2	31.1	41.0	33.5	33.3	44.1
15	29.0	28.9	37.9	31.3	31.2	41.1	33.6	33.4	44.3
16	29.1	29.0	38.0	31.4	31.3	41.2	33.7	33.5	44.4
17	29.2	29.1	38.2	31.5	31.4	41.4	33.8	33.6	44.5
18	29.3	29.2	38.3	31.6	31.5	41.5	33.9	33.7	44.7
19	29.4	29.3	38.5	31.7	31.6	41.6	34.0	33.8	44.8
20	29.5	29.4	38.6	31.8	31.7	41.8	34.1	33.9	45.0
21	29.6	29.5	38.7	31.9	31.8	41.9	34.2	34.0	45.1
22	29.7	29.6	38.9	32.0	31.9	42.1	34.3	34.1	45.2
23	29.8	29.7	39.0	32.1	32.0	42.2	34.4	34.2	45.4

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CAPO TEST ASTM C 900-19

S#	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)
1	34.5	34.3	45.5	36.8	36.6	48.7	39.1	38.9	52.2
2	34.6	34.4	45.7	36.9	36.7	48.9	39.2	39.0	52.4
3	34.7	34.5	45.8	37.0	36.8	49.0	39.3	39.1	52.5
4	34.8	34.6	45.8	37.1	36.9	49.2	39.4	39.2	52.7
5	34.9	34.7	45.9	37.2	37.0	49.3	39.5	39.3	52.9
6	35.0	34.8	46.1	37.3	37.1	49.4	39.6	39.4	53.0
7	35.1	34.9	46.2	37.4	37.2	49.6	39.7	39.5	53.2
8	35.2	35.0	46.3	37.5	37.3	49.7	39.8	39.6	53.3
9	35.3	35.1	46.5	37.6	37.4	49.9	39.9	39.7	53.5
10	35.4	35.2	46.8	37.7	37.5	50.0	40.0	39.8	53.6
11	35.5	35.3	46.9	37.8	37.6	50.1	40.1	39.9	53.8
12	35.6	35.4	47.0	37.9	37.7	50.3	40.2	40.0	54.0
13	35.7	35.5	47.2	38.0	37.8	50.4	40.3	40.1	54.1
14	35.8	35.6	47.3	38.1	37.9	50.6	40.4	40.2	54.3
15	35.9	35.7	47.5	38.2	38.0	50.8	40.5	40.3	54.4
16	36.0	35.8	47.6	38.3	38.1	51.0	40.6	40.4	54.6
17	36.1	35.9	47.8	38.4	38.2	51.1	40.7	40.5	54.7
18	36.2	36.0	47.9	38.5	38.3	51.3	40.8	40.6	54.9
19	36.3	36.1	48.0	38.6	38.4	51.4	40.9	40.7	55.1
20	36.4	36.2	48.2	38.7	38.5	51.6	41.0	40.8	55.2
21	36.5	36.3	48.3	38.8	38.6	51.7	41.1	40.9	55.4
22	36.6	36.4	48.5	38.9	38.7	51.9	41.2	41.0	55.5
23	36.7	36.5	48.6	39.0	38.8	52.1	41.3	41.1	55.7

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CAPO TEST ASTM C 900-19

S#	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)	Reading	Actual pullforce (KN)	Cube Strength (Mpa)
1	42.4	42.2	57.4	44.7	44.4	61.0	47.0	46.8	64.7
2	42.5	42.3	57.5	44.8	44.5	61.1	47.1	46.9	64.9
3	42.6	42.3	57.7	44.9	44.6	61.3	47.2	47.0	65.1
4	42.7	42.4	57.9	45.0	44.7	61.4	47.3	47.1	65.2
5	42.8	42.5	58.0	45.1	44.8	61.6	47.4	47.2	65.4
6	42.9	42.6	58.2	45.2	44.9	61.8	47.5	47.3	65.6
7	43.0	42.7	58.3	45.3	45.0	61.9	47.6	47.4	65.7
8	43.1	42.8	58.5	45.4	45.1	62.1	47.7	47.5	65.9
9	43.2	42.9	58.6	45.5	45.2	62.3	47.8	47.6	66.0
10	43.3	43.0	58.8	45.6	45.3	62.4	47.9	47.7	66.2
11	43.4	43.1	58.9	45.7	45.4	62.6	48.0	47.8	66.4
12	43.5	43.2	59.1	45.8	45.5	62.8	48.1	47.9	66.5
13	43.6	43.3	59.3	45.9	45.6	62.9	48.2	48.0	66.7
14	43.7	43.4	59.4	46.0	45.7	63.1	48.3	48.1	66.9
15	43.8	43.5	59.6	46.1	45.8	63.2	48.4	48.2	67.0
16	43.9	43.6	59.7	46.2	45.9	63.4	48.5	48.3	67.2
17	44.0	43.7	59.9	46.3	46.1	63.6	48.6	48.4	67.4
18	44.1	43.8	60.0	46.4	46.2	63.7	48.7	48.5	67.5
19	44.2	43.9	60.2	46.5	46.3	63.9	48.8	48.6	67.7
20	44.3	44.0	60.3	46.6	46.4	64.1	48.9	48.8	67.9
21	44.4	44.1	60.5	46.7	46.5	64.2	50.0	48.9	68.0
22	44.5	44.2	60.7	46.8	46.6	64.4	50.1	50.0	68.2
23	44.6	44.3	60.8	46.9	46.7	64.6	50.2	50.1	68.4

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APPENDIX E – CHLORIDE CONTENT FOR EXTRACTED CORES

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F&M ENGINEERING

CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
1	Transom 01, Core 52	0 - 25mm	0.05	0.34
		25 - 50mm	0.08	0.51
		50 - 75mm	0.10	0.63
		75 - 100mm	0.11	0.72
2	Transom 03, Core 48	0 - 25mm	0.04	0.25
		25 - 50mm	0.05	0.35
		50 - 75mm	0.08	0.49
		75 - 100mm	0.13	0.82
3	Transom 05, Core 45	0 - 25mm	0.09	0.57
		25 - 50mm	0.11	0.70
		50 - 75mm	0.13	0.83
		75 - 100mm	0.16	1.14
4	Transom 07, Core 50	0 - 25mm	0.07	0.49
		25 - 50mm	0.09	0.57
		50 - 75mm	0.15	1.00
		75 - 100mm	0.15	1.03
5	Transom 09 Core 51	0 - 25mm	0.09	0.62
		25 - 50mm	0.10	0.73
		50 - 75mm	0.11	0.79
		75 - 100mm	0.20	1.41

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
	F & M ENGINEERING KARACHI
Lab Assistant : S. Aiman Irshad	Lab Manager : Jawwad Naseem

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F&M ENGINEERING

CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
6	Transom 10, Core#01	0 - 25mm	0.10	0.64
		25 - 50mm	0.11	0.77
		50 - 75mm	0.15	1.03
		75 - 100mm	0.18	1.20
7	Transom 11, Core#03 ©	0 - 25mm	0.11	0.73
		25 - 50mm	0.15	0.97
		50 - 75mm	0.15	1.03
		75 - 100mm	0.19	1.23
8	Transom 12, Core # 06	0 - 25mm	0.05	0.29
		25 - 50mm	0.07	0.42
		50 - 75mm	0.07	0.46
		75 - 100mm	0.10	0.64
9	Transom 13, Core#07 ©	0 - 25mm	0.12	0.83
		25 - 50mm	0.13	0.86
		50 - 75mm	0.15	1.06
		75 - 100mm	0.17	1.16
10	Transom 14, Core #09	0 - 25mm	0.09	0.59
		25 - 50mm	0.07	0.50
		50 - 75mm	0.09	0.61
		75 - 100mm	0.12	0.83

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	**Lab Manager : Jawwad Naseem**

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
11	Transom 15, Core #11	0 - 25mm	0.09	0.60
		25 - 50mm	0.12	0.83
		50 - 75mm	0.13	0.90
		75 - 100mm	0.15	1.05
12	Transom 18, Core#13	0 - 25mm	0.10	0.66
		25 - 50mm	0.12	0.82
		50 - 75mm	0.15	1.03
		75 - 100mm	0.17	1.18
13	Transom 19, Core#14	0 - 25mm	0.01	0.08
		25 - 50mm	0.04	0.29
		50 - 75mm	0.09	0.59
		75 - 100mm	0.09	0.65
14	Transom 21, Core#21	0 - 25mm	0.09	0.59
		25 - 50mm	0.12	0.81
		50 - 75mm	0.14	0.95
		75 - 100mm	0.17	1.16
15	Transom 23 Core#22	0 - 25mm	0.07	0.43
		25 - 50mm	0.09	0.58
		50 - 75mm	0.01	0.08
		75 - 100mm	0.18	1.17

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	**Lab Manager : Jawwad Naseem**

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
16	Transom 25, Core#24	0 - 25mm	0.12	0.78
		25 - 50mm	0.14	0.91
		50 - 75mm	0.16	1.07
		75 - 100mm	0.18	1.20
17	Transom 27, Core #26	0 - 25mm	0.01	0.07
		25 - 50mm	0.05	0.36
		50 - 75mm	0.09	0.57
		75 - 100mm	0.11	0.76
18	Transom 29, Core#24	0 - 25mm	0.11	0.79
		25 - 50mm	0.15	1.02
		50 - 75mm	0.16	1.12
		75 - 100mm	0.17	1.16
19	Transom 31, Core #30	0 - 25mm	0.01	0.08
		25 - 50mm	0.02	0.16
		50 - 75mm	0.06	0.39
		75 - 100mm	0.09	0.57
20	Transom 33, Core#32	0 - 25mm	0.11	0.75
		25 - 50mm	0.13	0.88
		50 - 75mm	0.15	1.03
		75 - 100mm	0.18	1.18

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	**Lab Manager : Jawwad Naseem**

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
21	Transom 35, Core#34	0 - 25mm	0.15	0.98
		25 - 50mm	0.18	1.20
		50 - 75mm	0.20	1.32
		75 - 100mm	0.21	1.43
22	Transom 37, Core#36	0 - 25mm	0.10	0.65
		25 - 50mm	0.12	0.84
		50 - 75mm	0.18	1.21
		75 - 100mm	0.20	1.34
23	Pier 2 Core #55	0 - 25mm	0.15	1.03
		25 - 50mm	0.18	1.17
		50 - 75mm	0.19	1.29
		75 - 100mm	0.21	1.41
24	Pier 04 Core #01	0 - 25mm	0.07	0.43
		25 - 50mm	0.08	0.53
		50 - 75mm	0.11	0.75
		75 - 100mm	0.13	0.88
25	Pier 06 Core #04	0 - 25mm	0.18	1.21
		25 - 50mm	0.20	1.30
		50 - 75mm	0.21	1.39
		75 - 100mm	0.25	1.61

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
26	Pier 08	0 - 25mm	0.06	0.43
		25 - 50mm	0.09	0.57
		50 - 75mm	0.11	0.75
		75 - 100mm	0.15	1.03
27	Pier 10 Core#02	0 - 25mm	0.20	1.29
		25 - 50mm	0.21	1.40
		50 - 75mm	0.24	1.60
		75 - 100mm	0.30	1.99
28	Pier 11 (06)	0 - 25mm	0.05	0.35
		25 - 50mm	0.09	0.58
		50 - 75mm	0.16	1.03
		75 - 100mm	0.19	1.23
29	Pier 11 (05)	0 - 25mm	0.10	0.68
		25 - 50mm	0.17	1.11
		50 - 75mm	0.19	1.23
		75 - 100mm	0.21	1.41
30	Pier 11 Core #04	0 - 25mm	0.08	0.58
		25 - 50mm	0.15	1.02
		50 - 75mm	0.16	1.15
		75 - 100mm	0.20	1.37

Note : Chloride test was performed from exterior surface to interior surface.

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
31	Pier 12 Core #63 (Jacketing)	0 - 25mm	0.07	0.47
		25 - 50mm	0.09	0.60
		50 - 75mm	0.16	1.07
		75 - 100mm	0.19	1.27
32	Pier 12 ©	0 - 25mm	0.07	0.45
		25 - 50mm	0.08	0.58
		50 - 75mm	0.15	1.06
		75 - 100mm	0.18	1.22
33	Pier 13 Core #08	0 - 25mm	0.08	0.53
		25 - 50mm	0.14	0.98
		50 - 75mm	0.16	1.15
		75 - 100mm	0.20	1.38
34	Pier 16 Core #02	0 - 25mm	0.07	0.45
		25 - 50mm	0.08	0.57
		50 - 75mm	0.15	1.00
		75 - 100mm	0.19	1.28
35	Pier 16 Jacketing	0 - 25mm	0.04	0.30
		25 - 50mm	0.08	0.51
		50 - 75mm	0.13	0.84
		75 - 100mm	0.18	1.20

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	Lab Manager : Jawwad Naseem

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
36	Pier 17 Core #12	0 - 25mm	0.08	0.56
		25 - 50mm	0.10	0.70
		50 - 75mm	0.15	1.05
		75 - 100mm	0.18	1.26
37	Pier 20 Core #20	0 - 25mm	0.09	0.61
		25 - 50mm	0.15	1.02
		50 - 75mm	0.18	1.27
		75 - 100mm	0.21	1.48
38	Pier 22 Core #15	0 - 25mm	0.09	0.57
		25 - 50mm	0.14	0.96
		50 - 75mm	0.17	1.11
		75 - 100mm	0.20	1.33
39	Pier 24 Core #23	0 - 25mm	0.08	0.54
		25 - 50mm	0.14	1.00
		50 - 75mm	0.18	1.24
		75 - 100mm	0.22	1.56
40	Pier 26 Core #28	0 - 25mm	0.11	0.74
		25 - 50mm	0.15	1.01
		50 - 75mm	0.19	1.26
		75 - 100mm	0.20	1.35

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
41	Pier 26 Grid	0 - 25mm	0.07	0.50
		25 - 50mm	0.13	0.89
		50 - 75mm	0.17	1.11
		75 - 100mm	0.19	1.28
42	Pier 28 Core #44 ©	0 - 25mm	0.13	0.91
		25 - 50mm	0.17	1.15
		50 - 75mm	0.19	1.28
		75 - 100mm	0.21	1.43
43	Pier 28 Grid	0 - 25mm	0.11	0.75
		25 - 50mm	0.14	0.97
		50 - 75mm	0.17	1.13
		75 - 100mm	0.19	1.28
44	Pier 30 Core #27	0 - 25mm	0.12	0.79
		25 - 50mm	0.15	1.01
		50 - 75mm	0.18	1.16
		75 - 100mm	0.22	1.46
45	Pier 32 Core #31	0 - 25mm	0.08	0.55
		25 - 50mm	0.12	0.81
		50 - 75mm	0.15	1.00
		75 - 100mm	0.18	1.15

Note : Chloride test was performed from exterior surface to interior surface.

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CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
46	Pier 34 Core #33	0 - 25mm	0.08	0.51
		25 - 50mm	0.11	0.73
		50 - 75mm	0.15	1.03
		75 - 100mm	0.18	1.17
47	Pier 34 grid	0 - 25mm	0.07	0.50
		25 - 50mm	0.12	0.84
		50 - 75mm	0.17	1.11
		75 - 100mm	0.20	1.34
48	Pier 36 Core #35	0 - 25mm	0.08	0.57
		25 - 50mm	0.13	0.90
		50 - 75mm	0.19	1.26
		75 - 100mm	0.21	1.43
49	Girder 05 Core#47	0 - 25mm	0.27	1.46
		25 - 50mm	0.30	1.62
		50 - 75mm	0.34	1.88
		75 - 100mm	0.38	2.11
50	Girder 11 Core#60	0 - 25mm	0.15	0.83
		25 - 50mm	0.19	1.01
		50 - 75mm	0.21	1.14
		75 - 100mm	0.30	1.61

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
	F & M ENGINEERING KARACHI
Lab Assistant : S. Aiman Irshad	Lab Manager : Jawwad Naseem

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F&M ENGINEERING

CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
51	Girder 26 Core#43	0 - 25mm	0.16	0.87
		25 - 50mm	0.21	1.14
		50 - 75mm	0.26	1.41
		75 - 100mm	0.30	1.60
52	Girder 36 Core#37	0 - 25mm	0.15	0.85
		25 - 50mm	0.18	0.97
		50 - 75mm	0.23	1.27
		75 - 100mm	0.26	1.44
53	Deck Grid 3 Core#42	0 - 25mm	0.15	0.77
		25 - 50mm	0.18	0.88
		50 - 75mm	0.22	1.10
		75 - 100mm	0.25	1.25
54	Deck slab Grid 11 Core #40	0 - 25mm	0.11	0.54
		25 - 50mm	0.15	0.74
		50 - 75mm	0.20	0.98
		75 - 100mm	0.24	1.19
55	Deck Grid 19 ©	0 - 25mm	0.14	0.72
		25 - 50mm	0.17	0.83
		50 - 75mm	0.19	0.94
		75 - 100mm	0.22	1.11

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	Lab Manager : Jawwad Naseem

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F&M ENGINEERING

CHLORIDE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:	Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:	Nespak	**Date**	:	3/12/2021
Location	:	Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SECTION	CHLORIDE %	CHLORIDE BY WEIGHT OF CEMENT %
56	Deck slab Grid 27 Core #40	0 - 25mm	0.14	0.71
		25 - 50mm	0.17	0.82
		50 - 75mm	0.19	0.93
		75 - 100mm	0.21	1.05
57	Deck Grid 37 Core #38 ©	0 - 25mm	0.17	0.82
		25 - 50mm	0.19	0.93
		50 - 75mm	0.21	1.05
		75 - 100mm	0.27	1.32
58	Abutment (Near Grid 37)	0 - 25mm	0.15	0.77
		25 - 50mm	0.20	0.99
		50 - 75mm	0.21	1.06
		75 - 100mm	0.27	1.36

Note : Chloride test was performed from exterior surface to interior surface.

Reviewed by :	Approved by :
Lab Assistant : S. Aiman Irshad	Lab Manager : Jawwad Naseem

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APPENDIX F –SULPHATE CONTENT FOR EXTRACTED CORES

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F&M ENGINEERING

SULPHATE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No**	:	J01-0003-10/21
Client	:Nespak	**Date**	:	3/12/2021
Location	:Jam Sadiq Bridge			

S.NO	SPECIMEN NO	SULPHATE %	SULPHATE BY WEIGHT OF CEMENT %
1	Transom 01, Core 52	1.33	8.72
2	Transom 03, Core 48	1.45	9.54
3	Transom 05, Core 45	1.48	9.87
4	Transom 07, Core 50	1.25	8.47
5	Transom 09 Core 51	1.32	9.44
6	Transom 10, Core#01	1.21	8.18
7	Transom 12, Core # 06	1.21	8.09
8	Transom 11, Core#03 ©	1.35	8.77
9	Transom 13, Core#07 ©	1.35	9.34
10	Transom 14, Core #09	1.22	8.38
11	Transom 15, Core #11	1.45	9.93
12	Transom 18, Core#13	1.25	8.45
13	Transom 19, Core#14	1.28	8.83
14	Transom 21, Core#21	1.37	9.11
15	Transum 23 Core#22	1.38	9.23

Reviewed by:	Checked by:
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Lab Technician: S. Aiman Irshad	**Lab Manager: Jawwad Naseem**

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F&M ENGINEERING

SULPHATE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No** :	J01-0003-10/21
Client	:Nespak	**Date** :	3/12/2021
Location	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	SULPHATE %	SULPHATE BY WEIGHT OF CEMENT %
16	Transom 25, Core#24	1.44	9.73
17	Transom 27, Core #26	1.41	9.53
18	Transom 29, Core#24	1.14	8.03
19	Transom 31, Core #30	1.21	8.18
20	Transom 33, Core#32	1.43	8.18
21	Transom 35, Core#34	1.39	9.39
22	Transom 37, Core#36	1.45	9.93
23	Pier 2 Core #55	1.48	9.87
24	Pier 04 Core # 49	1.21	8.07
25	Pier 06 Core # 46	1.232	8.11
26	Pier 08, Core # 41	1.254	8.36
27	Pier 10, Core # 02	1.45	9.54
28	Pier 11 (06), Core # 56	1.48	9.87
29	Pier 11 (05), Core # 57	1.38	9.14
30	Pier 11 Core #04	1.38	9.72

Reviewed by:	Checked by:
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Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

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SULPHATE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No** :	J01-0003-10/21
Client	:Nespak	**Date** :	3/12/2021
Location	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	SULPHATE %	SULPHATE BY WEIGHT OF CEMENT %
31	Pier 12 Core #63 (Jacketing)	1.20	8.03
32	Pier 12 ©, Core #05	1.25	8.69
33	Pier 13 Core #08	1.22	8.55
34	Pier 16 Core #02	1.35	9.31
35	Pier 16 Jacketing, Core # 58	1.35	9.12
36	Pier 17 Core #12	1.25	8.74
37	Pier 20 Core #20	1.36	9.58
38	Pier 22 Core #15	1.09	7.33
39	Pier 24 Core #23	1.10	7.73
40	Pier 26 Core #28	1.26	8.48
41	Pier 26, Core # 29	1.12	7.57
42	Pier 28 Core #44 ©	1.24	8.38
43	Pier 28, Core # 54	1.15	7.88
44	Pier 30 Core #27	1.35	8.88
45	Pier 32 Core #31	1.25	8.25

Reviewed by:	Checked by:
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F&M ENGINEERING

SULPHATE CONTENT OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No** :	J01-0003-10/21
Client	:Nespak	**Date** :	3/12/2021
Location	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	SULPHATE %	SULPHATE BY WEIGHT OF CEMENT %
46	Pier 34 Core #33	1.48	9.87
47	Pier 34, Core #39	1.37	9.26
48	Pier 36 Core #35	1.24	8.38
49	Girder 05 Core#47	1.57	8.63
50	Girder 11 Core#60	1.68	9.13
51	Girder 26 Core#43	1.65	8.97
52	Girder 36 Core#37	1.59	8.78
53	Deck Grid 3 Core#42	1.74	8.53
54	Deck slab Grid 11 Core #40	1.95	9.65
55	Deck Grid 19 ©	1.91	9.70
56	Deck slab Grid 27 Core #40	1.87	9.30
57	Deck Grid 37 Core #38 ©	1.97	9.80
58	Abutment (Near Grid 37)	1.85	9.27

Reviewed by:	Checked by:
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Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

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APPENDIX G – CONCRETE COMPOSITION TEST

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CONCRETE COMPOSITION OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No**	**: J01-0003-10/21**
Client	:Nespak	**Date**	**: 3/12/2021**
Contractor	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	DENSITY (Kg/m^3)	CEMENT CONTENT %	CEMENT CONTENT (Kg/m^3)	AGGREGATE CONTENT %
1	Transom 01, Core 52	2304.58	15.20	350.30	81.00
2	Transom 03, Core 48	2318.06	15.20	352.35	81.00
3	Transom 05, Core 45	2267.29	15.00	340.09	81.40
4	Transom 07, Core 50	2247.14	14.80	332.58	81.70
5	Transom 09 Core 51	2275.80	14.00	318.61	82.70
6	Transom 10, Core#01	2235.03	14.8	330.78	81.7
7	Transom 11, Core#03 ©	2482.21	15	372.33	81.4
8	Transom 12, Core # 06	2275.19	15.4	350.38	80.9
9	Transom 13, Core#07 ©	2454.39	14.5	355.89	82
10	Transom 14, Core #09	2401.02	14.5	348.15	82
11	Transom 15, Core #11	2291.96	14.6	334.63	81.9
12	Transom 18, Core#13	2395.28	14.8	354.50	81.7
13	Transom 19, Core#14	2234.56	14.50	324.01	82.00
14	Transom 21, Core#21	2164.40	15.00	324.66	81.40
15	Transum 23 Core#22	2354.60	15.00	353.19	81.40

Reviewed by :	Approved by :
Lab Assistant : S.Aiman Irshad	Lab Manager : Jawwad Naseem

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CONCRETE COMPOSITION OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No**	**: J01-0003-10/21**
Client	:Nespak	**Date**	**: 3/12/2021**
Contractor	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	DENSITY (Kg/m^3)	CEMENT CONTENT %	CEMENT CONTENT (Kg/m^3)	AGGREGATE CONTENT %
16	Transom 25, Core#24	2493.74	14.80	369.07	81.70
17	Transom 27, Core #26	2183.07	14.80	323.09	81.70
18	Transom 29, Core#24	2261.12	14.2	321.08	82.4
19	Transom 31, Core #30	2351.97	14.8	348.09	81.7
20	Transom 33, Core#32	2351.29	15	352.69	81.4
21	Transom 35, Core#34	2267.89	14.8	335.65	81.7
22	Transom 37, Core#36	2325.87	14.6	339.58	81.9
23	Pier 2 Core #55	2212.61	15	331.89	81.4
24	Pier 04 Core # 49	2172.12	15	325.82	81.4
25	Pier 06 Core # 46	2428.55	15.2	369.14	81.00
26	Pier 08, Core # 41	2254.69	15	338.20	81.40
27	Pier 10, Core # 02	2469.60	15.2	375.38	81.00
28	Pier 11 (06), Core # 56	2274.13	15	341.12	81.40
29	Pier 11 (05), Core # 57	2204.15	15.1	332.83	81.40
30	Pier 11 Core #04	2281.50	14.2	323.97	82.4

Reviewed by :	Approved by :
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Lab Assistant : S.Aiman Irshad	**Lab Manager : Jawwad Naseem**

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CONCRETE COMPOSITION OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No**	**: J01-0003-10/21**
Client	:Nespak	**Date**	**: 3/12/2021**
Contractor	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	DENSITY (Kg/m^3)	CEMENT CONTENT %	CEMENT CONTENT (Kg/m^3)	AGGREGATE CONTENT %
31	Pier 12 Core #63 (Jacketing)	2247.54	15	337.13	81.4
32	Pier 12 ©, Core #05	2479.61	14.4	357.06	79.5
33	Pier 13 Core #08	2202.29	14.3	314.93	82.3
34	Pier 16 Core #02	2428.87	14.5	352.19	82
35	Pier 16 Jacketing, Core # 58	2268.28	14.8	335.71	81.7
36	Pier 17 Core #12	2427.32	14.3	347.11	82.3
37	Pier 20 Core #20	2121.64	14.2	301.27	82.4
38	Pier 22 Core #15	2353.13	14.8	348.26	81.7
39	Pier 24 Core #23	2324.19	14.2	330.04	82.4
40	Pier 26 Core #28	2308.10	14.8	341.60	81.7
41	Pier 26, Core # 29	2419.50	14.8	358.09	81.7
42	Pier 28 Core #44 ©	2434.25	14.8	360.27	81.7
43	Pier 28, Core # 54	2278.42	14.6	332.65	81.9
44	Pier 30 Core #27	2322.96	15.2	353.09	81
45	Pier 32 Core #31	2187.21	15.2	332.46	81

Reviewed by :	Approved by :
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F&M ENGINEERING

CONCRETE COMPOSITION OF HARDENED CONCRETE (BS 1881 - 124)

Project	:Jam Sadiq Bridge	**Job No**	**: J01-0003-10/21**
Client	:Nespak	**Date**	**: 3/12/2021**
Contractor	:Jam Sadiq Bridge		

S.NO	SPECIMEN NO	DENSITY (Kg/m^3)	CEMENT CONTENT %	CEMENT CONTENT (Kg/m^3)	AGGREGATE CONTENT %
46	Pier 34 Core #33	2496.31	15	374.45	81.4
47	Pier 34, Core #39	2333.60	14.8	345.37	81.7
48	Pier 36 Core #35	2407.88	14.8	356.37	81.7
49	Girder 05 Core#47	2187.21	18.2	398.07	77.5
50	Girder 11 Core#60	2219.80	18.4	408.44	77.2
51	Girder 26 Core#43	2321.23	18.4	427.11	77.2
52	Girder 36 Core#37	2275.19	18.1	411.81	77.6
53	Deck Grid 3 Core#42	2209.03	20.4	450.64	74.8
54	Deck slab Grid 11 Core #40	2232.14	20.2	450.89	75
55	Deck Grid 19 ©	2150.31	19.7	423.61	75.7
56	Deck slab Grid 27 Core #40	2254.69	20.1	453.19	75.2
57	Deck Grid 37 Core #38 ©	2289.49	20.1	460.19	75.2
58	Abutment (Near Grid 37)	2216.59	20	443.32	74.8

Reviewed by :	Approved by :
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Lab Assistant : S.Aiman Irshad	Lab Manager : Jawwad Naseem

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APPENDIX H – CARBONATION TEST ON EXTRACTED CORES

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CARBONATION OF HARDENED CONCRETE (BS EN 14630)

Project	: Jam Sadiq Bridge	**Job No**	: J01-0003-10/21
Client	: Nespak	**Date**	: 29-11-2021
Contractor	: Jam Sadiq Bridge		

S.No	Specimen No	Core No	Molarity of indicator	Depth of Carbonation (mm)
1	Transom 01	Core # 52	0.10%	Non Carbonated
2	Transom 03	Core # 48	0.10%	Non Carbonated
3	Transom 05	Core # 45	0.10%	Non Carbonated
4	Transom 07	Core # 50	0.10%	Non Carbonated
5	Transum 09	Core # 51	0.10%	Non Carbonated
6	Transom 10	Core # 01	0.10%	Non Carbonated
7	Transom 11	Core # 03	0.10%	Non Carbonated
8	Transum 12	Core # 06	0.10%	Non Carbonated
9	Transom 13	Core # 07	0.10%	Non Carbonated
10	Transom 14	Core # 09	0.10%	Non Carbonated
11	Transom 15	Core # 11	0.10%	Non Carbonated
12	Transom 18	Core # 13	0.10%	Non Carbonated
13	Transom 19	Core # 14	0.10%	Non Carbonated
14	Transom 21	Core # 21	0.10%	230mm
15	Transom 23	Core # 22	0.10%	Non Carbonated

NOTE : Carbonation test was performed in situ on Extracted cores and their length can be larger than the cores on which compressive strength test was performed

Reviewed by:	Checked by:
Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

F&M ENGINEERING

CARBONATION OF HARDENED CONCRETE (BS EN 14630)

Project	: Jam Sadiq Bridge	**Job No**	: J01-0003-10/21
Client	: Nespak	**Date**	: 29-11-2021
Contractor	: Jam Sadiq Bridge		

S.No	Specimen No	Core No	Molarity of indicator	Depth of Carbonation (mm)
16	Transom 25	Core#24	0.10%	Non Carbonated
17	Transom 27	Core #26	0.10%	Non Carbonated
18	Transom 29	Core # 25	0.10%	50mm
19	Transom 31	Core #30	0.10%	27mm
20	Transom 33	Core#32	0.10%	Non Carbonated
21	Transom 35	Core#34	0.10%	Non Carbonated
22	Transom 37	, Core#36	0.10%	Non Carbonated
23	Pier 2	Core #55	0.10%	50mm
24	Pier 04	Core #49	0.10%	75mm
25	Pier 06	Core #46	0.10%	68mm
26	Pier 08	Core #41	0.10%	42mm
27	Pier 10	Core#02	0.10%	50mm
28	Pier 11 (06)	Core#56	0.10%	Non Carbonated
29	Pier 11 (05)	Core#57	0.10%	Non Carbonated
30	Pier 11	Core #04	0.10%	Non Carbonated

Reviewed by:	Checked by:
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Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

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CARBONATION OF HARDENED CONCRETE (BS EN 14630)

Project	: Jam Sadiq Bridge	**Job No**	: J01-0003-10/21
Client	: Nespak	**Date**	: 29-11-2021
Contractor	: Jam Sadiq Bridge		

S.No	Specimen No	Core No	Molarity of indicator	Depth of Carbonation (mm)
31	Pier 12 (Jacketing)	Core #63	0.10%	Non Carbonated
32	Pier 12 ©	Core #05	0.10%	Non Carbonated
33	Pier 13	Core#08	0.10%	Non Carbonated
34	Pier 16	Core #02	0.10%	Non Carbonated
35	Pier 16 Jacketing	Core#58	0.10%	Non Carbonated
36	Pier 17	Core#12	0.10%	Non Carbonated
37	Pier 20	Core #20	0.10%	75mm
38	Pier 22	Core #15	0.10%	130mm
39	Pier 24	Core #23	0.10%	Non Carbonated
40	Pier 26	Core #28	0.10%	Non Carbonated
41	Pier 26	Core #29	0.10%	Non Carbonated
42	Pier 28 ©	Core #44	0.10%	Non Carbonated
43	Pier 28	Core #54	0.10%	Non Carbonated
44	Pier 30	Core# 27	0.10%	Non Carbonated
45	Pier 32	Core #31	0.10%	Non Carbonated

Reviewed by:	Checked by:
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Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

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F&M ENGINEERING

CARBONATION OF HARDENED CONCRETE (BS EN 14630)

Project	: Jam Sadiq Bridge	**Job No**	: J01-0003-10/21
Client	: Nespak	**Date**	: 29-11-2021
Contractor	: Jam Sadiq Bridge		

S.No	Specimen No	Core No	Molarity of indicator	Depth of Carbonation (mm)
46	Pier 34	Core #33	0.10%	Non Carbonated
47	Pier 34	Core #39	0.10%	Non Carbonated
48	Pier 36	Core#35	0.10%	Non Carbonated
49	Girder 05	Core#47	0.10%	Non Carbonated
50	Girder 11	Core#60	0.10%	Non Carbonated
51	Girder 26	Core#43	0.10%	Non Carbonated
52	Girder 36	Core#37	0.10%	Non Carbonated
53	Deck Grid 3	Core#42	0.10%	Non Carbonated
54	Deck slab Grid 11	Core #40	0.10%	130mm
55	Deck Grid 19 ©	Core #28	0.10%	75mm
56	Deck slab Grid 27	Core #40	0.10%	Non Carbonated
57	Deck Grid 37 ©	Core #38	0.10%	Non Carbonated
58	Abutment (Near Grid 37)	Core #53	0.10%	Non Carbonated

Reviewed by:	Checked by:
	F&M ENGINEERING KARACHI
Lab Technician: S. Aiman Irshad	Lab Manager: Jawwad Naseem

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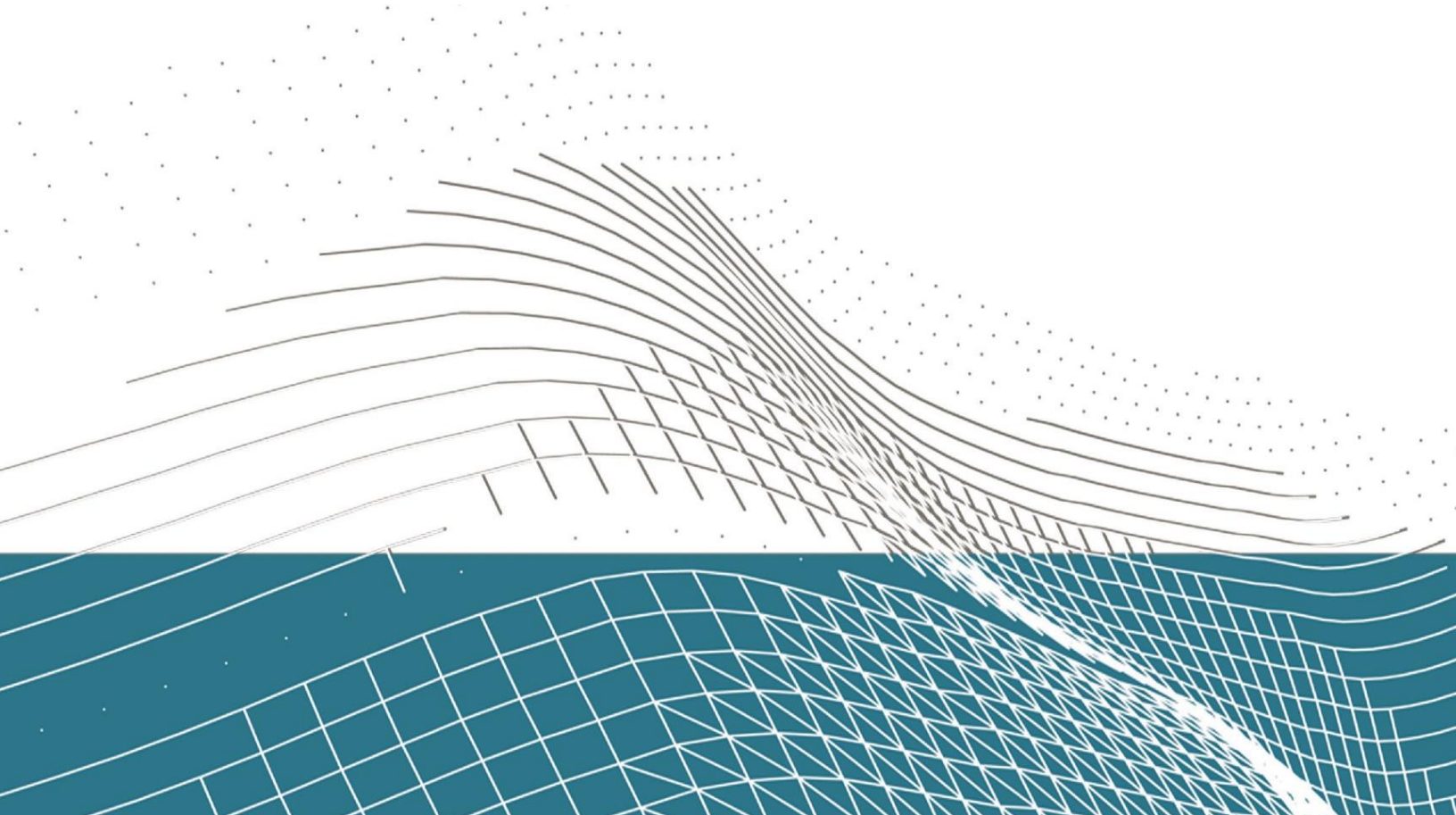
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